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Research Observations and Lessons Learned for the Future Combat Systems

Charlotte H. Campbell
Human Resources Research Organization

May H. Throne
Barbara A. Black
Carl W. Lickteig
U.S. Army Research Institute

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Armored Forces Research Unit

U.S. Army Research Institute for the Behavioral and Social Sciences

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ZITA M. SIMUTIS
Director

Technical Review by

Margaret S. Salter, U.S. Army Research Institute
Dee Andrews, U.S. Air Force Research Laboratory

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This brief summarizes some of the important observations and lessons learned from training research and development conducted by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) over the past 15 years. Its purpose is to assist Future Combat Systems (FCS) designers and developers as they formulate plans for the systems and for the training that will accompany the systems. The topic summaries cover the need for a Master Training Plan, training development and implementation concerns, training and performance support and system issues, and a few non-training and non-system observations. The reference list (Appendix B) gives the complete citation for readers who need more information, and the reference matrix at Appendix C shows which documentation sources each topic summary is based on. In selected cases, more complete summaries on specific techniques or principles are provided in Appendix D. Finally, Appendix E contains a compendium of research issues that remain to be investigated.

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Charlotte H. Campbell
Human Resources Research Organization

May H. Throne
Barbara A. Black
Carl W. Lickteig
U.S. Army Research Institute

Armored Forces Research Unit
Barbara A. Black, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

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RESEARCH OBSERVATIONS AND LESSONS LEARNED FOR THE FUTURE COMBAT SYSTEMS

FOREWORD

The U.S. Army has initiated transformation to an Objective Force equipped with Future Combat Systems (FCS) to be more responsive, deployable, agile, versatile, lethal, survivable, and sustainable to meet the full spectrum of future missions. Development and fielding of the FCS is critical to the success of the Army's Transformation. Training is recognized as an essential component of the FCS Program, and considerable thought and analysis have been given to the driving requirements for training. One of the key drivers concerns the reality that FCS and the Objective Force are new – revolutionary rather than evolutionary. The design and development of the evolving System of Systems is broad and multifaceted, and the scope of work involved in developing collective and individual training is correspondingly complex.

For many years, the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has been involved in the development of embedded training concepts and methods. As initial planning and acquisition documents indicate that the primary method for implementing Objective Force training will be embedded training, ARI, at its Armored Forces Research Unit at Fort Knox, undertook to create a compendium of observations and lessons learned from the many research reports and products generated over the past 15 years.

This Research Product presents the findings from the effort. Nearly 100 reports were reviewed, and interviews were conducted with a dozen experts in training who had participated in the research. Almost 400 individual "nuggets" of information were collected, sorted, and summarized. The summaries are succinct – rarely will they provide sufficient information for a designer or developer who does not already understand something about training principles to go design some training. For those who are interested in more information, documentation sources for each topic as well as more complete summaries on specific techniques and principles are provided in the appendixes.

The preliminary results of this effort were presented to Mr. Jim Shiflett, the FCS training leader for Science Applications International Corporation (SAIC), which is the Lead Systems Integrator (LSI) for FCS, on 16 December 2002. The purpose of this product is to assist FCS designers and developers as they formulate plans for the systems and for the training that will accompany the systems.

MICHAEL G. RUMSEY
Acting Technical Director

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On a report such as this, the credit for any value conferred to the reader goes to the many researchers and military thinkers whose work inspired this effort. The reference section gives a list of all of the reports and articles reviewed. Special credit is due to all of those authors. We also need to recognize Ms. Deborah Marcum (HumRRO), who served as manager of the database containing all of the research report data, observations, and lessons learned.

We are especially indebted to those individuals who contributed additional thoughts and insights as the report was being written, notably:

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- Mr. Charles Heiden, HumRRO, ADTP, Fort Knox.
- Mr. William T. Holden, Jr., HumRRO, ADTP, Fort Knox.
- Dr. Angela I. Karrasch, ARI, AFRU, Fort Knox
- Dr. James W. Lussier, ARI, AFRU, Fort Knox.
- Dr. Larry Meliza, ARI, SSRU, Orlando.
- Dr. Kathleen A. Quinkert, Chief, TRADOC Scientific Coordination Office, Fort Monroe.
- Ms. Margaret S. Salter, ARI, IFRU, Fort Benning.
- Dr. Bruce S. Sterling, U.S. Army Research Laboratory (ARL), Fort Knox.

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Appendixes

RESEARCH OBSERVATIONS AND LESSONS LEARNED FOR THE FUTURE COMBAT SYSTEMS

Introduction

The U.S. Army has initiated transformation to a lighter, more mobile Objective Force that can operate readily within joint and coalition environments. This force will be responsive, deployable, agile, versatile, lethal, survivable, and sustainable. These characteristics will enable Objective Force units to see first, understand first, act first, and finish decisively. Objective Force units will possess knowledge-based capability to respond rapidly and decisively across the full spectrum of military operations through deployment with the Future Combat Systems (FCS). The FCS is designed to be a system of systems that is fully networked to ensure rapid and complete sharing of information. The FCS will be fielded initially in mobile combined arms Units of Action, roughly equivalent to today's brigades.

Throughout its history, the Army has undergone transformation frequently, if not continuously. Over the last 10-15 years, the pace of transformation has quickened as the Army has engaged in more diverse, non-traditional missions, while at the same time becoming more digitally equipped. Previous research and development (R&D) efforts have examined training, performance support, and feedback methods for these new missions and environments. There is a potential for much useful information that can be gathered from these past efforts that will have an impact on training Units of Action equipped with FCS.

Given that the Army is in the early stages of transformation, it is essential to review previous relevant R&D efforts and collect the lessons learned as well as the observations of the key researchers involved. These research observations and lessons learned will serve as a starting point for training Units of Action, helping to ensure that available findings are applied appropriately and previous mistakes are not repeated. This report summarizes some of the important observations and lessons learned from training research and development conducted by the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) over the past 15 years. Its purpose is to assist Army designers and developers as they formulate plans for the Future Combat Systems (FCS) and for the training that will accompany the systems.

ARI's long history and reputation as a leader in training research and development (R&D) is evidenced in thousands of research reports, technical reports, study reports, and research products. ARI scientists and sponsored contractors have published findings and analyses in the open literature and presented at professional conferences for both military and industry audiences. The domain is not restricted to conventional training methods, but draws on ARI expertise in human factors, cognitive processes, organizational theories, military operations and doctrine, individual and collective performance improvement, and technological system design. The body of information has long been a source of ideas and building blocks for researchers and decision-makers, but had not been assembled into a coherent summary or searchable database.

The intent of this project is to provide a very basic compilation of research observations and lessons learned to inform FCS developers and Unit of Action (UA)[1] training developers. It is not a comprehensive database of all ARI work, nor does it incorporate information from non-ARI sources. However, it provides training developers with a succinct collection of recommendations and guidelines for use as training for the FCS goes forward.

[1] Underlined terms are defined in Appendix A.

Method

A number of sources were examined. For the most part, we relied on documentation in the form of research reports, technical reports, and study reports published by ARI. One of those sources (Leibrecht, Johnston, Black, & Quinkert, 2002) discusses a "knowledge elicitation" process for use in eliciting tacit knowledge from experts. We employed a modification of the process for this report that was more focused on published documentation than on interviews. We also, however, interviewed a dozen of the principal researchers who had performed and directed work on multiple projects, both ARI and contractor, to gather more global observations that would not be found in the separate reports. Nearly 400 discrete "nuggets" were entered into the database from these sources.

The nuggets were then grouped to form topics and specific subject areas within the broader topics. Topic definitions were written and refined to focus the content, although it should be noted that the integrated nature of training development requirements precludes production of non-overlapping topic areas. Summaries were prepared to present the best wisdom from the nuggets – recommendations, suggestions, opinions, strong research findings, and alternatives are all included. Several readers reviewed and refined each summary, ensuring that the nuggets were adequately represented.

At the same time, all of the information was entered into a relational database using Microsoft Access®. At the conclusion of the project, the database, with data-entry forms, queries, and report templates, was added to ARI's collection of research and study products. This database is expandable and searchable, and should be maintained and used as FCS development continues and as additional ARI research is completed.

As we were gathering and analyzing the observations and lessons learned, we encountered one that encouraged us to continue the process. It is presented here for your edification.

> As the number of 'lessons learned' continues to grow, we are continually reminded to learn old lessons better, even as we amass new ones. There is a need to review and analyze those lessons in the course of development projects. While all of the information is available in the separate reports, it would be a benefit to developers to have a single compendium or database containing lessons and even the larger lessons that emerge from content analysis of the individual lessons. (Campbell, Deter, et al., 1999, p. 33)

Organization of the Report

The topic summaries are presented in an order that made sense to the authors. The first topic addresses the need for a Master Training Plan – not to imply that it has not been thought of, but to reinforce the need for such a plan and to offer a few reminders of what should be included, based on the research. The next several topics are related to training development and implementation. We then discuss training and performance support and system issues. The final topic summary touches on a few non-training and non-system observations – they are not training, but they are too important to leave out.

Each topic summary contains a short introductory paragraph that defines the issue. The subject areas within each topic also begin with introductory paragraphs, followed by a cautionary note: what will happen if the issue is not addressed. The remaining portion of the subject area discussion presents the imperatives or suggestions drawn from the reviews. Appendix A contains definitions

of acronyms and terms that may not be familiar to all readers; such terms have been underlined like this in the topic summaries.

The summaries are succinct – rarely will they provide sufficient information for a designer or developer who does not already understand something about training principles to go design some training. However, the reference list (Appendix B) gives the complete citation for readers who need more information, and the reference matrix at Appendix C shows which documentation sources each topic summary is based on. In selected cases, more complete summaries on specific techniques or principles are provided in Appendix D. Finally, Appendix E contains a compendium of research issues culled from the sources, issues that remain to be investigated.

Discussion

This is by no means a comprehensive summary of all R&D findings related to training, nor is the list of reports in Appendix B exhaustive. For the most part, we fixated on embedded training (ET)[2] and lessons learned that may have an impact on training Units of Action equipped with FCS. Despite all of the obstacles that remain, we can more readily visualize such training occurring in vehicles than in equipment carried by dismounted soldiers (e.g., the Land Warrior systems). Additionally, the development of simulation systems for dismounted troops is currently less mature than other development, so that deriving lessons learned is more straightforward in R&D related to maneuver units.

Many of the outstanding issues are presented in Appendix E. Although the list is short (two pages) it is quite dense, and yet only scratches the surface. These issues were identified in published reports; a team of military trainers could easily identify many more.

[2] For a brief review and definitions of ET, see Throne and Burnside (2003).

The Big Picture: The FCS Master Training Strategy

A recurring theme in training research and development concerns the need for planning and analysis. This is a requirement not only for discrete training support packages (TSPs) or training programs, but also for the Big Training Program. That is, there is a need for an overarching strategy that specifies the TSPs that will be needed. To all appearances, the FCS team is investing significant energy and thoughts in developing an overall training plan that covers individual and collective training, multiple training locales (schoolhouse, new equipment training (NET), unit-based), and an assortment of training environments

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Define the master training plan

The FCS Master Training Strategy must address the full array of training approaches that have been shown to be effective in previous training programs, specify how and when they are to be used, and designate the role of the institution, the units, and the individual.

If the Master Plan does not cover alternative approaches, a strategy for when to train with what, and details of who does what, then it is not yet ready for use.

- The integrated training strategy should address (at a minimum) ET, structured training, synchronous and asynchronous distance learning, distributed and fixed site simulation based training, and live training.
- The training approach should clearly distinguish between training, concept exploration, and mission rehearsal, and address all three.
- Train leaders first, because leaders are the trainers for their units and so must be expert in the training methodology and doctrine specific to the Objective Force.
- Before a significant bank of TSPs is available, the strategy should prescribe what types of training should be developed for what purposes. Once the TSPs begin to become available, the strategy should designate specific TSPs for specific purposes.
- A number of roles need to be assigned to the institution, the unit, and the individual, including the roles of training developer, distributor, evaluator, manager, and trainer.
- The training management system needs to be connected to every element of the strategy.
- Training issues include the training burden. One hope (not a method) is that institutional training will not be lengthened and the training burden will not fall on field commanders. Rather, soldiers will arrive at their assignments with all of the skills necessary to perform competently, or will train themselves using distributed training approaches once they leave initial training. This is not going to happen by itself, but will require support materials and resources.

Integrate the master plan

Even bigger than the training plan is the whole FCS concept, and the pieces need to be connected explicitly.

Training is not the only way to ensure expert performance, but it is essential, and cannot succeed unless it is an integrated part of the whole FCS concept, including systems development and personnel issues.

A range of non-training issues is discussed in the section on *Performance Improvement.* Only two are described here.

- The strategy needs to address technology insertion plans – not only for the initial FCS systems but also for the training, and not only to cover training upgrades to match FCS upgrades but also to match emerging training technologies.
- For the multi-skilled soldier (MSS) concept, the training design is one of several aspects, including force design, military occupational specialty (MOS) design, implementation, and sustainment. It will be necessary to balance and make tradeoffs between constraints with respect to training requirements, training resources, and training technology. Appendix D, section D.1, contains a proposed roadmap for achieving the MSS goal.

Information

One component of the training strategy will be information and education for potential users of the training.

If developers of the Master Training Strategy do not anticipate and recognize expectations, and manage them through information and education, widespread adoption of the strategy will be very difficult.

Education can be thought of as "fear reduction," as a way to overcome reluctance or resistance due to ignorance (which we mean in the nicest possible way to indicate absence of knowledge, not absence of intelligence). Some of the elements of this component of the plan will be:

- Clearly define what can (and cannot) be trained or partially trained in each type of training (e.g., ET, distributed training). This should be a required product from the collaborative efforts of the system development team (SDT) and training design team (TDT).
- Include education for trainers and leaders on the nature and value of each type of training, and on how to make training decisions that are based on unit proficiency and identification of training objectives.
- Provide training management enablers and decision-making aids to training managers and UA leaders.
- Acknowledge and work to dispel the perceptions that constructive and virtual simulations are unrelated to live simulation.
- Incorporate the same cognitive strategies in the education component as you would in the training itself.

Resources and activities

As the Master Training Strategy is constructed, elements that require resourcing must be identified.

Calling for training support activities without resourcing them is like any vision without funding – it is a fantasy, not a vision.

The nature of the resourcing and funding will vary among components of the strategy, of course, but some things to keep in mind include:

- The Army needs a unified training/training management/training support strategy that synchronizes training and training support resources demanded by the new operational environment and pattern of operations.
- If the burden of training will fall to the unit, there will need to be a realistic appraisal of preparation and delivery resource requirements.
- Training development will take advantage of technologies that will automate many of the processes, incorporate reusable learning objects and components, and allow for streaming data collection to permit training evaluation. But the basic Instructional Systems Design/Systems Approach to Training (ISD/SAT) process of analyze – design – develop – implement – evaluate remains as an effective and comprehensive approach.
- A more effective formalized link between institution and units must be constructed and embraced. Whether this is done through focused integrated process teams (IPTs), communities of practice (COPs), or some other collaborative mechanism, the sharing of information and plans is essential to effective growth.
- Incorporate activities for sustaining and updating training.
- Ensure that the strategy attends to a range of audience mixes, including:
    - Individual, team, and collective training.
    - Single echelon and multiechelon training.
    - Skill training for units equipped with Legacy (or current) systems, Stryker (the Army's medium-weight system that serves as the interim between Legacy and FCS), and FCS, separately and together.
    - Institutional, unit, and professional self-development training.
    - NET.
    - Integrated training for active component (AC) and reserve component (RC) units and for joint and multinational coalition forces.

Big part of big picture: the Training Design Team (TDT)

The training within the strategy is going to be designed and developed by – whom? This is not just a matter of reading proposals and reviewing prior experience – it also involves knowing what you want – defining standards and criteria – before you go looking for it.

Without a clear understanding and vision of what the TDT should do and how it should operate, much time will be lost in forming a plan and beginning substantive work.

Experience over the past 25 years (for many of the experts interviewed) suggests the following:

- There needs to be only one government decision-maker monitoring and directing the team. This is the person who should be able to interpret and enforce or modify the Statement of Work (SOW) provisions, and he/she should be given some autonomy and flexibility.
- Integrated teams of government and contractors are necessary, working closely and sharing information openly.

- Teams working on the training should be multidisciplinary, to include instructional design, psychology and behavioral scientists, and multimedia programmers in addition to military experts.
- It may be advantageous to draw team members from multiple companies, to bring together more expertise and cover a greater breadth and depth of knowledge and experience.
- The teams should not be insulated from other teams or from on-going decision-making.

Analysis

Repeatedly, studies and reports have stressed the importance of early and thorough analysis, documentation of decisions and rationale, and concurrence by all stakeholders. Five specific focus areas for analysis were identified.

Training audience

When we accept that the foundation of UA training is ET (UAMBL, 2002), we need to also accept that there will be less direct management and facilitation of the actual training by observer/controllers (O/Cs) or contractors. The UA personnel will be largely self-directed, often without humans to help the user through the selection and execution process.

If we do not have accurate definitions of the multiple training users in mind, the training will not be used or, if used, will not be optimally effective.

To arrive at those accurate definitions of the users, the TDT needs to clearly and thoroughly identify the intended audience for each training component.

- The learning styles within target training audience need to be identified.
- Information on experience and entry skills will be needed.
- Methods of access to the training environments and capabilities must be documented.

Tasks and standards

Performance standards define what we want performers to be able to do. To the extent that the standards are clear and correct, training can lead users to mastery.

If performance standards are not identified and clearly addressed in the training design, the training flounders and has no purpose.

For FCS UA tasks, the TDT must identify standards for individual and collective performance during the course of analysis. It is essential that stakeholders examine and agree on performance standards.

- Maintain crosswalks of objectives and training component content.
- Ensure the stated objectives are addressed as measure of performance (MOPs) and measure of effectiveness (MOEs) in the measurement and feedback mechanisms.
- Make use of concept exploration capabilities offered by simulation environments to capture task processes and standards.

Conditions

The Objective Force may be operating in any of a vast array of environments – jungle, desert, urban, mountainous – and under various combinations of conditions – nuclear/biological/chemical (NBC), joint, interagency, multiservice. Analysis must examine and document the combinations.

Tasks are condition-specific; without explicit definition of how they are performed in different conditions, the developed TSPs will be inadequate.

Specifying the task conditions is as important as specifying tasks and standards.

- In effect, a matrix of tasks x conditions is required as a definition of the training domain.

- It will be impossible to develop and expect units to use TSPs for every task under every possible condition; ratings of uniqueness, probability, and criticality will also be needed.
- On the other hand, the TDT can and should continue to expand the domain matrix and prepare for emerging missions. As automated development tools become available and deployment-immediate training becomes feasible, the need for comprehensive TSP libraries will diminish.

Modeling expert performance

With ET (or any computer-delivered adaptive training), there is a great opportunity to build training components that will lead novices to perform tasks like experts do, at least at a journeyman level.

Unless we understand expert performance and task structures, we will fail in designing expert training.

- The TDT needs to capture both the novice and the expert user process, including how they perform tasks in the system, codify the performance hierarchy, group tasks, and understand the task sequencing.
- Provide input to SDT so that the system itself is designed to facilitate how experts perform.

Analysis methods

In addition to reviewing doctrinal guidance on a regular basis and incorporating the latest information, the TDT should select one (or more, as appropriate) tested and proven methods for job, task, needs, and work place analyses. Several are summarized in Appendix D (sections D.2 to D.5).

Unless a deliberate method for analysis is adopted and followed, the foundations on which to build the training will be weak and will not support growth.

- Different methods are appropriate for different situations or types of training; the TDT will need to study and understand the methods prior to adopting one or elements of one.
- Certain information about tasks will always be needed: criticality, frequency, learning difficulty, performance latency, consequences, consequence latency, intrinsic feedback, and amount of supervision.
- There is a divergence of opinion on how widely the analytic process can be distributed. While geographical distribution is becoming a less serious problem with more sophisticated means of communication, there is still a risk of disconnects if the methods and products are not synchronized.

Objectives – What to Train

We are hopeful that job and task analysis will tell us what to train *(see Analysis)*. In advance of having that information, prior research already points to several areas that will need to be addressed. They are presented below, grouped into four general classes of objectives.

Digital skills

The Army is already becoming digital, and the FCS should, by all rights, be a continuation and acceleration of the current trend. Training objectives should continue to include digital skills.

The extensive research on battle command and control in digital environments must be considered in designing the training, or we will find ourselves relearning old lessons.

We know that user skills go beyond the ability to simply create digital products. They also include the ability to employ digital products to enhance mission performance. Analyses have resulted in definition of four classes of digital skills, and have also identified specific performance problems that could be addressed through training in these skills (see Appendix D, sections D.6 and D.7).

- Networking skills are concerned with maintaining connectivity throughout a mission.
- Basic operator skills are concerned with using the network to transmit and manage information.
- Basic user skills are tactical skills performed using digital systems, where digitization does not offer a distinct tactical advantage – that is, the digital system is no more than an alternative mechanism.
- Exploitation skills are tactical skills performed using digital systems, where digitization offers a distinct tactical advantage – that is, the digital system is a powerful tool that clearly enhances performance.

Back-up skills

Digitization and other technology solutions do not remove the requirement to train conventional and back-up skills.

Back-up analysis must become part of the mindset of decision-makers from conceptualization of systems through implementation.

Back-up considerations must be integrated into procurement and development processes, doctrine development, task analysis, and training development.

- Analysis to identify conventional and back-up tasks and to determine appropriate mix of conventional, back-up, and digital training required for the UAs employing FCS should use the methodology developed for Force XXI analyses (summarized in Appendix D, section D.8).
- The principal factor in successful application of the methodology is for training analysts and subject matter experts (SMEs) to be extremely knowledgeable about FCS operation and employment at multiple echelons.
- Further analysis should include update of existing doctrine identifying relevant tasks as FCS or back-up; a comprehensive needs assessment for tasks requiring repair or workaround back-ups; risk assessment on tasks with back-up requirements (probability and impact).

- Whether it is thought of as back-up or as the new operational environment, UAs will likely need to operate alongside Legacy and Stryker forces, and need to train for those situations.

Individual competencies

Task analysis on not-yet-developed systems will be challenging, to say the least *(see Analysis)*. In the process, however, it will be important to not lose sight of the non-task skills and abilities that contribute to success.

We know enough about non-task skills and their role in expert performance to include them in the bank of training objectives.

Those non-task-specific skills cut across tasks, and can be trained in the context of task- and mission specific training. Some of the prime areas include:

- Competencies: Defined as the ability to get things done, whatever they are, by adaptively employing existing inventories of knowledge, abilities, attitudes, and skills, competency-based training is an alternative (or complement) to traditional task-based training. Competency-based training should enable UA leaders to transition rapidly from one kind of mission to another.
- Stress resistance: Researchers have found that, under high stress, leaders use their experience but misuse their intelligence; under low stress, they use their intelligence but misuse their experience. Experience in stressful conditions lowers vulnerability to stress and increases task structure and therefore increases the leader's situational control. Such leadership experience improves self-efficacy, and also interpersonal relations with subordinates.
- Situational awareness: Leaders and soldiers must be trained to trust the situational awareness support system integrated in FCS but to avoid over-reliance on it. Instead, they must integrate all sources and forms of information and use that information to make better decisions quickly, not deferring decisions while waiting for more perfect situational awareness.
- Information management: Cognitive strategies for information management such as techniques to filter, sort or group, prioritize and interpret incoming information can be trained, and leaders must have practice in integrating the information received in order to synchronize actions. They will need to define information requirements, apply appropriate information filters, and formulate and execute information search strategies.
- Learning how to learn: The multi-skilled soldiers of the UA must be perpetually learning, and must be trained and motivated to deepen and broaden the skills they acquire in initial entry training (IET), largely through self-education by means of distributed training and distance learning (DL).
- Adaptive thinking: Training and situational practice in adaptive thinking, coupled with identification and training of minimum essential tasks, can extend the benefits of structured training. Soldiers will need to be able to identify and adjust to information technology requirements and quickly master individual and collective learning requirements.
- System management: Leaders and staffs must thoroughly understand how robotic forces work and what rules they follow in order to effectively employ

them. They must acquire simple operational knowledge as well as more advanced understanding of how to exploit capabilities and knowledge, and must master conceptual as well as mechanical aspects of command and control (C2).

Staff and team skills

In addition to individual competencies, we also have the ability to work on staff and team skills, effectively multiplying the utility of individual proficiency.

If training for staffs and teams is no more than individual training in groups, the result will be proficiency of a group of independently working individuals, rather than team proficiency.

Analysis and research have already identified a set of staff skills that can be trained and have also provided information on how they should be trained:

- Monitor, process, analyze/evaluate, communicate, coordinate, integrate, recommend, disseminate, synchronize – these skills can be trained in small staff groups using scenario-based training (one such use is summarized in section D.9, Appendix D).
- Shared mental models: Leaders and their staffs need to learn how to share their knowledge and understanding quickly in order to form a common vision of the situation, work as a group on making decisions, and understand, individually and collectively, the actions required.
- Training of stability operations and support operations (SASO) missions should consist primarily of leader training at brigade and higher, while lower echelons should continue to focus on warfighting operations. The resulting discipline, team building, and familiarization with chain of command will strengthen small-unit capability on all types of missions.
- There are strong recommendations for how leaders should acquire and develop proficiency in leadership skills:
    - Increase experiential learning.
    - Ensure stress (i.e., battle friction) in advanced learning.
    - Use chain-of-command training.
    - Develop team cohesion and coherence.
    - Fine-tune decision-making processes.
    - Establish common tactical scenarios.

Training Design

Training has a goal – to improve performance – and a target audience – the trainee, the learner. During analysis, the training audience was defined in terms of experience, prior learning, styles, and job situation, among other things *(see Analysis)*. That information, plus results of research on learning and human factors, guides training design decisions. The observations and lessons learned are presented in the context of seven topics.

Training focus

While training for the UAs is still at the start of the overall analysis process, it is critical that the analysis include not only task analysis, but also a clear definition of the focus for each training component (as well as a vision of how the components themselves fit together, *see Big Picture).*

If the focus for each component is not stated, understood, and addressed in design, the resulting training will be both incomplete and duplicative, and users will be unable to determine what component to conduct.

Throughout the design process for the system and the training, the TDT needs to prepare and publish a clear and thorough statement of the focus of each training component.

- Identify the full range of tasks covered for each component, based on a learning hierarchy of minimum essential skills through high-level exploitation of capabilities and organizations. Multiple tasks and training objectives may be addressed in a single component, if it increases the efficiency of the training.
- Ensure the purpose of the training is clearly understood by training managers, training developers, training audience members, and leaders.
- Use the information on training objectives to design and conduct training evaluations *(see Evaluation).*

Learner styles

The effectiveness of the training will depend on how well it addresses learner needs and matches how learners learn. Although there are a number of relatively universal learning principles, it has been shown that different individuals learn differently, and groups learn differently from individuals.

If training design decisions do not both address common learning principles and also account for a substantial portion of different learning styles, they will be inappropriate for a substantial portion of learners.

There is a significant body of research on learning styles, far too much to cover here. Some of the widely appropriate principles for design include:

- Adopt a model where the learner constructs the new knowledge through interactions; avoid passive reception of data.
- Given an analysis of the training audience *(see Audience)*, build on their prior knowledge to introduce new concepts or procedures.
- Make content relevant and meaningful. Generic situations that are deliberately not relevant to the learner environment are rarely effective.
- Vary the scenario situations, presentations, and demands to increase flexibility and keep learner interest up. Scenario nesting should be kept reasonable to minimize the risk of leaving some participants behind. Ensure realism at all levels, but also ensure active participation opportunities for all participants.

- Give the learner and learner teams choices and autonomy over the pace and sequence of the instruction, when feasible.
- Incorporate adaptable content for different prior skill sets. The embedded system should have the capability to detect learner needs and provide the appropriate presentation.
- Problem-solving strategies may slow acquisition but are effective in supporting skills that are adaptable to new situations.
- Include deliberate practice to identify shortcomings in staff processes and conduct staff integration training.
- Provide repeated practice, performance feedback, and increasingly difficult and complex situations.
- Use short tactical vignettes to provide standardized iterative training.
- A behaviorist approach is more useful for basic skill learning, while a constructivist approach should be used as learners are refining their skills and focusing on application.
- When there are instructors, they can effectively act as co-learners by designing tasks wherein learners solve real world problems, reflect on skills used to manage their own learning, address misconceptions in their thinking, categorize problems around themes and concepts, and generally take ownership for their own learning.
- As the system itself is being designed, the TDT must provide input to the SDT so that the information on learning styles is addressed, allowing the training to leverage system capabilities.

Skill acquisition and retention

Design decisions should include training principles and approaches that support swift skill acquisition, longer retention, and more efficient relearning.

Many of the tasks and skills will be new, and training approaches that do not reinforce learned skills in order to resist decay would be a waste of resources.

There are specific training principles and approaches that contribute to more efficient skill acquisition, longer retention, and faster re-acquisition. For example:

- Especially for more basic operator tasks and other procedural tasks, covering the underlying principles as well as operational steps yields more flexible knowledge that is more resistant to skill decay.
- Combining instructional principles has a multiplicative effect.
- In addition to step-by-step basic training, give skills training and drills, with feedback opportunities, to build automaticity. Maximize initial learning to require practice beyond meeting of minimal standards.
- Optimize scheduling of refresher training based on prediction of the rate of skill decay.
- Optimize effectiveness of refresher training by using technologies (e.g., video previews) to reestablish context.
- Test the skills being trained.

- Provide spaced rather than massed practice.
- Use task-oriented context-relevant training.
- Use peer tutoring.

Expert skill training

Most formal training will aim to develop journeyman skill levels, but the long-term training goal is to produce hyper-proficient expert individuals and teams who can fully exploit technology.

If the training is not designed to model and shape expert performance, based on the processes of expert performers, we will have pedantic training and minimally competent users.

Continually, show the bridge between the expert process and the learner's current state.

- Design the training to mimic expert performance.
- Group tasks for training to encourage the grouping that makes sense to experts in performance.
- Address minimum essential skills with drills and procedural training; use a performance objectives approach for higher-level skills. This will allow soldiers to learn-transfer-adapt to achieve hyper-proficiency. A method for developing performance objectives training materials is shown in Appendix D, section D.10.
- Identify and highlight similarities and differences between the learner's current proficiency and expert performance to facilitate learning, retention, and adaptability.

Training sequence

The training has to be done in some sequence – it can't all be done simultaneously.

If some sequences are better than others, designers must incorporate the optimal sequences in the overall training plan, rather than leaving it totally random.

- Provide users with a general understanding of system capabilities and train-up expectations during the initial training.
- Incorporate progressive skill building approach by attention to enabling and terminal skills.
- Provide multiple entry points and paths to ensure adequate practice while crediting prior experience or readiness.
- Allow time and provide support for drills to facilitate skill consolidation, automaticity, and the benefits of cumulative practice.

Large-scale v. small-scale exercises

During design, there will be decisions on whether to create large-scale or small-scale exercises. This is not an "either/or" situation – it depends on the training objectives.

Building only large-scale or only small-scale exercises for training ignores the reality that different training structures are suited for different purposes.

Small-scale exercises are less resource intensive to implement; large-scale exercises can give trainers more bang for the buck. Designers should use both approaches, as well as other models (small group, dyad/triad/quadad) as appropriate. Just as training builds

from enabling objectives to terminal objectives, exercise scale should build as part of the overall training strategy *(see Big Picture).*

- Provide small-scale focused training as well as multiechelon training with full inclusion of assets.
- The difficult but necessary effort is to keep smaller scale exercises focused on a small group and a selected, limited event. Without this focus, the exercise grows into a "little war" and the purpose of having easily implemented focused exercises is defeated
- Large-scale exercises may be cost-effective if they are reserved for use after participants have learned their own jobs.
- Provide training components and guidance on sequencing to allow UAs to work from individual skills to small groups to staffs and leaders, rolling in subordinate staffs and subordinate units along the way.
- Incorporate multiechelon programs, one-up/one-down.
- Reserve "a-way" approaches for training at lower echelons.
- Consider and include a variety of approaches to allow for a more human-centric approach.

Training support packages

Whether training is embedded, computer- or simulation-supported outside the FCS, or platform, TSPs will be required.

The technology can take us a long way on the road to training that is delivered seamlessly, transparently, and effortlessly – but only if the TSPs, the learning management system (LMS), and the unit training management system (UTMS) are designed in concert to do that.

- Allocate resources for designing and developing resilient and robust TSPs that cannot only tolerate tailoring but also encourage it.
- Ensure the TSP elements (e.g., scenario, training audience materials) are tailored to the users and purpose, rather than to a predefined structure.
- Use structured training, which calls for a focus on specified training objectives, opportunities for practice, and performance feedback on those objectives.
- All of the TSP contents – including information on how to select the appropriate training, instructions on how to access and implement the training, and content – must be immediately understandable and usable by all potential users.
- Provide tools for use of self-assessment techniques that link user observations to the training objectives.
- Don't assume that O/Cs can reliably provide feedback without some guidance from developers. Section D.11 in Appendix D describes train-the-trainer materials to include in a TSP.
- Take advantage of materials and instructional techniques that reside in existing, proven, structured training products, and convert them to new needs as appropriate *(see Development).*

- Disseminate existing TSPs to all potential users, and also to potential developers. Virtual dissemination, via a centralized accessible repository, must be supported by active and aggressive information pushes.
- Knowing the accessibility obstacles (e.g., bandwidth), make sure that the intended users will be able to access the training.

Training Development

Training development begins with analysis and design, discussed in separate sections. It contains continual evaluation activities, which are also covered in a separate section. That said, there remain many observations and lessons learned related to the portions of development that involve the design and actual construction of the training materials or infrastructure. They are grouped under three general headings.

Use of user and expert input

However careful we are in ensuring that training is ideally suited to the user, at some point we actually need to talk to users – both those who will be using the training and those who will be their leaders. Their input and reactions are essential to ensuring that the products will be accepted, used, and useful.

If we fail to involve users and experts in planning and decision-making, we operate in a vacuum and have little hope of producing training that will be adopted.

Obtain early input to task analysis, training designs, and training products from diverse and representative users and innovative thinkers.

- Analyze and evaluate breadth and depth of experience before using the input. Unexamined input is no better than no input at all. Look for logical thinking, foundations in reality, linkages to other accepted models, and hard data.
- Get users' input at multiple points in the process. The advantage of using the same users and experts all along the way is that they will be familiar with prior thinking and decisions. However, there is advantage in tapping fresh minds, to ensure that the decisions are critically reviewed and the design process unbounded.
- Input must reflect not only how things are done now, but also visions of how the future will look.
- Remember that users will also include the people who have to manage and sustain the training, as well as facilitators (O/Cs and the like) and contractor/trainers. Using their input will ensure they will be able to support the training.

Development approaches

A deliberate and methodical approach to development can be swift and flexible while still ensuring attention to detail. The TDT should use the ISD model or one of the many variations that have been documented (summarized in Appendix D, sections D.12 through D.16; also see sections D.2 through D.4).

Beginning training development without a plan and a method guarantees a haphazard and minimally useful product.

In the case of FCS, and in fact in any case of simultaneous system and training development, the deliberateness of the ISD model may appear cumbersome and unworkable; in fact, it is even more critical that the approach be deliberate, in order to ensure the linkage between current status and decisions. Be prepared: There is a clear need to incorporate features of rapid prototyping and flexible component-based construction to facilitate continual updates.

- Use existing products and a conversion approach when the changes in systems, organizations, or doctrine are variations on existing conditions.

- For any such conversion effort, document the changes and the rationale so that the next wave of conversions can be executed rapidly and accurately. Be aware that conversion is not a short cut to full development.
- Likewise, use a conversion approach to keep up with changes in delivery modes and training technologies.
- However, do not be wedded to conversion, forsaking development of innovative training solutions.
- Use the core exercise set identification process in the case of new organizations or missions. This process is shown in Appendix D, section D.15.
- In general, for training that is going to be linked vertically (i.e., mutually supporting across echelons in terms of scenarios or tasks), try to design down and develop up. That is, design beginning with the higher echelon, but then build the training and the TSPs, based on that design, from the lower echelon.
- Exercises and training elements will need a built-in mechanism for accommodating modifications. By means of reusable and sharable components within flexible instructional programs and TSPs, automated tools to conjoin those components into remixed instructional programs and TSPs, and larger scale automated tools to configure the elements of the training system into a remastered system, training developers and units may have a chance of staying abreast of technology and other developments.

Developer tools

In the long run, it will be more efficient to create and distribute tools for modifying or converting existing training products than to continue to create new training. Giving thought and resources to developing those tools right now will pay off down the road.

Without tools to facilitate and simplify the efforts of training developers, we will be continuously spending time looking up methods and existing products, rather than being able to leverage those items, and we will continue to deny users the opportunity to tailor their training.

Tool development should parallel training development. Any process that the TDT finds itself doing more than once should be a candidate for tooling.

- During the early training and tool development process, the TDT should use scripting and programming methods that support flexible modifications and thus are amenable to tooling.
- The UAs will need tools to modify training for specific circumstances and needs.
- Training managers will need tools to modify measures and feedback and generate appropriate evaluation and feedback materials.

Training Implementation

Methods for implementing training will generally be part and parcel of the training component and the associated TSP. But efficient and effective training will need to be supported by a well-thought-out training infrastructure, embodying strategies and plans as well as a range of resources and support mechanisms. Instructors, surge teams (personnel who assist units with first time implementation of more complex exercises), O/Cs, and other experts will continue to be an integral part of the implementation plan. Given a continuing structured program of support, from education and information through exercise preparation to conduct of the exercise and feedback facilitation, units are able to participate in a wide range of training elements. Similarly, instructors will be available for students in distributed individual instruction situations. The lessons learned concerning the implementation of training are presented within eight topic areas.

Access issues

Successful and effective implementation of high-tech training, such as embedded or simulation-based training, requires that the target users have all of the equipment and TSP materials needed to conduct the training.

The best TSP in the world is useless if users are unable to use it.

The requirements are different for different types of training:

- Distance learning approaches require up-to-date computer hardware, software, and high-speed Internet access with sufficient bandwidth for the intended TSP.
- Embedded training requires users to be in their vehicles or on their network stations, unless there are mechanisms for replicating the training in other environments.
- Virtual and constructive simulations at fixed sites require some amount of co-location, even if several simulation sites are linked with distributed systems.
- Until automated measurement systems are sufficiently mature to independently handle all of the analysis, feedback, and coaching duties, O/Cs will be needed *(but see Analysts, below).*
- Access requirements include making time available for using the TSP, and being able to fence that time off from other requirements.

Multiple delivery modes

If access problems are associated with availability of training equipment, a partial solution is to provide a range of options for training implementation.

If each component of the training program for FCS is available via just one gate, a significant number of the intended users may be shut out.

Include, in addition to ET, other modes of delivery:

- Distance learning, via Internet or computer-based. There is a high rating of student satisfaction with these methods, and training effectiveness has been demonstrated for certain applications.
- Delivery via hand held systems (e.g., personal digital assistant [PDA]). These have also been rated as satisfactory by students, especially for declarative and procedural tasks. Greatest effectiveness comes with voluntary use.
- Use of a variety of training aids, devices, simulators, and simulations (TADSS) in live training allows users to get the value of added training time and repeated practice.

- Pay attention to how TSPs are delivered in order to maximize use.

Analysts and O/Cs

The access problem may concern availability of O/Cs. Using O/Cs with expert military credentials and comprehensive TSP guidance can be the key to effective collective training, but it can also be very costly and difficult to staff.

Given that expert O/Cs are needed but too costly and rare to support training requirements, training designers may need to "do more with less."

One potential solution (described in slightly more detail in Appendix D, sections D.17 and D.18) links two approaches in order to do more with less.

- Use Combat Training Center (CTC) O/Cs as centralized core groups of analysts, linked electronically to the UA in training. This approach increases the ratio of units trained to analysts, and bridges the gap from homestation to CTC by using the same analysts.
- Provide instrumentation and automated data collection and analysis for the analyst.

Whether centralized analyst approach is used or the more common on-site O/C/analyst approach, several elements are critical:

- O/C expertise and experience, both as a warfighter and as a trainer.
- Support, in terms of TSP guidance and time for adequate preparation.
- Instruction on what is available and how to use it.

Flexible training support

Recent experience and observation have indicated that, for individual and collective task-oriented training, a structured training approach is effective. Experience also shows, however, that the users will almost always want to change the training – to better address their training need or simply to put their own thumbprint on the exercise. Fortunately, structured training can be very flexible.

Rejecting structured training approaches as rigid or inflexible is shortsighted and ill-advised, resulting in loss of a powerful and adaptable tool for skill acquisition.

The strength of structured training is in providing events that ensure the unit will have to practice selected tasks, regardless of their battle plan.

- Training managers need to be educated, by means of the TSP itself, on how to modify the TSP without losing the advantages of structure.
- The structure allows and supports the possibility that users can themselves develop training exercises along with the TSP materials.

Managing TSPs

As UAs modify existing TSPs or even create their own training, there will be apprehensions that the training is not doctrinally correct or is not employing good training techniques.

No matter how good the training development tools are, unit-developed training that is not reviewed and approved will be regarded with suspicion and may not be used again.

Expert tools can help to ensure appropriate products *(see Development)*, and repositories of approved products can be constructed. But the perceived need for centralized review will still exist (particularly, of course, if the expert tools are not

provided to or used by units). The research in this area provides recommendations but no proven solutions.

- Even with a repository, the Army will need a mechanism for proponent review and approval of TSPs (both proponent- and user-developed) before storing them in the repository.
- Stored TSPs will require maintenance to preserve doctrinal currency.
- The repository for TSPs needs to be centralized but still accessible and secure.
- A virtual private network (VPN) could provide a high level of security while satisfying the Army Training Information Architecture (ATIA) principle that data be logically centralized, but physically dispersed.
- Units will need ongoing education and information about what is available and how to get it.

Simulation environments

Virtual and constructive simulations will remain useful for some time. However, the TDT needs to make intelligent choices about when and how to use them.

Simulations – whether fixed site, distributed, or embedded – are not the universal training solution (the silver bullet) but they do have some specific utility.

A good simulation in a well-executed environment offers control, realism, instrumentation for reliable measurement and replay, efficiency, and effectiveness. Everyone wants efficiency and effectiveness, but control, realism, and instrumentation requirements are relative.

- Control, or standardization, permits carefully designed replays of scenarios with the same or different conditions, allowing deliberate practice and skill building. For simple instruction or for tasks where job aiding is prevalent, multiple practice opportunities may be superfluous.
- Realism is required to permit users to see outcomes of decisions and actions. If the focus for the training will be on the decision rather than a dynamic outcome, simulation environments are not necessary. If the outcome is a long time in developing, the simulation may not be a good use of time.
- Likewise, realistic simulation systems can represent systems or troops for tactical realism and cues to participants, but should only be used if the realism is essential to the training objective.
- If there is nothing to measure in the course of an exercise, that is, if the training is process- rather than product-oriented, then instructional features such as measurement and replay will be of scant utility.
- Until simulation environments provide agents for all non-live roles, developers will need to allow for role-players, especially in SASO exercises. More than move and shoot training will be needed, and simulation environments are currently less adequate outside of move and shoot.
- Desktop or other types of reconfigurables allow wider participation for somewhat less cost and space requirements. They are also vastly useful for concept exploration.
- Synthetic theatres of war, with linked simulation environments, have distinct training potential for certain tasks (e.g., battle damage assessment, indirect fire

support, commander's recon, battle monitoring, recon tracking, and land management).

- To be useful, the simulation environments should also have integrated tools such as automated message generation, eavesdropping, exercise flags, and multiple observation perspectives.

Sustain and manage content

Once training is available for implementation, it will still require sustainment – to add options, maintain currency, incorporate new technologies, and so on.

Marketable shelf life of TSPs, without sustainment, can be as short as 6 months; without sustainment, it will be perceived as irrelevant and outdated.

If TSPs are not updated frequently, users will perceive that no one is attending to the training. If updates are too frequent, however, users will be confused by the appearance of multiple versions. The change may be purely cosmetic, such as changing the "last updated" date. More likely, the change will include new training opportunities. Not only does the sustainment need to happen, but it needs to be systematic, controlled, and communicated.

- The Army must design and implement mechanisms for fielding, sustaining, and updating programs, just as it does for operational systems and training devices.
- The Army should designate how and by whom the training is managed and sustained (currency).
- As the TSPs are built, they should be tested to ensure they are manageable by the designated managers, with a centrally managed universal training support system.
- Embeddedness should permit training to be tethered to its source/maintainer, who must also ensure that alternate versions are changed in concert.
- Users will tolerate irregularities for a short time, but they should be fixed in a timely fashion.
- Program resources must be allocated for feedback, reviews, and updates.
- It will be necessary to stabilize systems for some periods of time – UAs cannot train on software that is always changing. Instead, the Army should institute block changes, where the system stays the same for a period of time, then *all* upgrades are done in a 2-week period and *everyone* gets them.

Training management system

As individuals and UAs participate in various training activities, a centralized tracking and management system will be needed.

If the training gets used but no one knows what has been done, it will be impossible to plan additional training or training development.

The training management system will serve at least two functions:

- Managing training implementation: The system should keep track of all the pieces, what the soldier or UA has done, how well, what's next, and links among repositories for records.
- Managing training development: Data on the training that is being used will inform training developers on what implementation models are succeeding and

what TSPs are being ignored. The information should be useful in maintaining the overall training program for FCS UAs.

Evaluation

The concept of evaluation has a plethora of applications in training and system design. "Test and evaluation" is a familiar requirement for systems developers, and the requirement is rarely waived. By the same token, evaluation of training should be required. There are a number of facets to evaluation in the context of training, here presented under two general headings.

Formative evaluation

Formative evaluation involves the testing and reviewing that is done during the development process, which then leads to revisions in the training prior to fielding for operational use. It means doing our best to ensure that the training is accurate, understandable, useful, accessible, and effective – before putting it in the hands of users.

If we allow training to be fielded for use without formative evaluation, we have no idea whether the training can be understood or used by the target audience – the real customer.

The TDT needs a full battery of formative evaluation tools and needs to understand when to use them.

- Have training materials reviewed by training experts as well as military content experts.
- Try out the training with both experts and novices who represent the training audience.
- Conduct rigorous system trials and user trials, but maintain flexibility in introducing modifications on the fly; document modifications and reasons.
- In pilot testing, ensure that users can understand the implementation plan for the training and seem enthusiastically willing to conduct the training. If not, use the collected data to identify obstacles, and remove them.
- In pilot testing, ensure that users are able to perform the training objectives to standard. If not, use the collected data to redesign the training, refine the materials, or make corrections so that objectives will be achieved.
- Take advantage of the existing methods for evaluating the training support materials (summarized in Appendix D.19, section D.19).
- Get input from multiple sources and weight the input in accordance with your judgment of the credibility of the user. Do not base decisions on data from only one segment of the domain.

Summative evaluation

Summative evaluation is usually conducted as the training is fielded for operational use. More importantly, it refers to those activities and objectives related to the completion of the training: whether the users are able to use their learning on the job and whether the performance of the organization overall is improved because of the training provided to individuals or groups within the organization.

Without summative evaluations, there is no evidence of return on investment for the training.

Because major decisions could be made on the basis of the summative evaluation, planning and execution should be rigorous and thorough.

- Identify the evaluation goals and issues and select reliable measures to address those areas.

- Use the measures of performance (MOP) and measure of effectiveness (MOE) *(see Performance Measurement)* also for evaluation of the training programs themselves.
- Maintain scientific rigor in data collection and analysis; flexibility and modifications during the evaluation are acceptable and appropriate in the formative evaluation but not in summative evaluation.
- Take advantage of the methods for training effectiveness analysis (summarized in Appendix D, section D.20).

Performance Measurement

In order for training to lead to improved performance or certified proficiency, there must be evaluative feedback; in order to provide that feedback, there must be measurement. For FCS, automated measures are expected to be the most common type, although other approaches may also be needed. One important observation is that measurement needs to address what should be measured, not only what can be measured. Prior research yields performance measurement imperatives in four areas.

Measuring performance standards

Performance standards are what we measure performance against; to tell us whether or not the user has gained mastery of the training content. It is not sufficient to state the standards – they also have to be measurable. To the extent that the standards are clear and correct, and performance is measured during training and assessed against those standards, we can be sure that the training is appropriate and that the FCS leaders, soldiers, and UAs have achieved their training objectives.

If performance standards are not identified, stated, and measured, training becomes "check-the-block" and gives us no assurance of competency, much less proficiency.

For FCS and UA tasks, standards for individual and collective performance will have been identified during the course of analysis and will be stated as the training objectives *(see Analysis and Design)*. The TDT must construct metrics for assessing achievement of the objectives *(see Evaluation)*.

- Ensure MOPs and MOEs are clear and can be reliably assessed.
- Ensure the MOPs and MOEs are valid measures of the performance that they are meant to address.
- Ensure the MOPs and MOEs are acceptable to users and training managers and appropriate for the performance standards they address.

Automated measurement protocols

With embedded and other computer-based training, automated and objective measurement of activities is a given. Translating the raw data into useful feedback presentations or summary indicators of proficiency is a necessary next step.

If automated measures are not developed beyond raw data to evaluative feedback and understandable presentations that are linked to the established standards, the data will be clutter and of no use to users or training managers.

The TDT needs to attend to analysis and feedback in consideration of automated measures as much as to data collection. Take full advantage of the system's capability to get the data, analyze it to produce summary measures, show the results, and make assessments of the quality of the performance.

- Establish the link between MOPs and MOEs to tell *why* things happened, not only what happened.
- Measures/data must be clearly linked to the battlefield conditions and to the performer, and must address human and system behaviors related to C2 performance. For example, measurement of four objectives used for staff training – monitor, process, analyze, and communicate – should be supported by the system.
- Evaluate and validate the measures and relationships, and work with individuals and units to ensure the feedback is effective.

- The system must provide not only data recording, but also reduction, management, and analysis capabilities.
- Ensure automated measures used in training are closely aligned with any performance support systems (see *Performance Support Systems*).
- Early and continual communication with the SDT will be essential to ensuring that the FCS itself will support the automated measuring and analysis designed.

Non-automated protocols

Even though intelligent agent technologies are evolving rapidly, they are not yet ready to replace expert observation and interpretation of performance. Automated measures are not the only answer.

If we discontinue use of expert observers, analysts, and coaches in training, we will lose input that is not available any other way, and will also lose the opportunity to allow experts to analyze their own behaviors.

Don't hesitate to use traditional methods in addition to automated measurement to ensure broad coverage of performance assessment.

- Trained observers are currently the best way to put automated measures outputs into a meaningful context, but they will require training and guidance to ensure the reliability and validity of their output.
- For more complex decision making tasks, using one-on-one active coaching or mentoring is effective.
- Self-reports are also valid: Information about a unit's progress can be gained by simply asking questions of unit leaders and members. Other techniques include think aloud verbal protocols, query and probe techniques. Both objective and subjective measures have been developed and investigated.
- Keep an eye on the physical environments in which the UA soldiers will operate – it may require more space than is available to have observers at the user's shoulder. Look for ways to employ surrogate measures – those that indicate performance – rather than requiring the observer to have eyes on the user.
- Don't rely on just one type of data – think broadly about collecting information besides button pushes (e.g., audio and video recording, eye-tracking).

Skill indicators

The body of work with digital skill indicators provides examples of MOPs and MOEs for individual and collective measures.

Training developers can start from scratch and reinvent methods for identifying appropriate MOPs and MOEs, or they can work smart and consult the collected information amassed on digital skill definition.

The real value of considering the findings from digital work is in how the lessons were gathered, analyzed, and used, as much as what the lessons were.

- A scaleable, searchable repository for collecting and cataloging lessons should be designed and set up early, before experience with FCS begins to yield information, so that information is adequately catalogued.

- Topics for the repository can begin with the topics that came out of the digital experience. Examination of these findings and how they were garnered (summarized in Appendix D, sections D.21 and D.22) can help lead the TDT to the appropriate MOPs and MOEs for UAs.
- Experiments in simulation using early conceptual models of FCS capabilities should be targeted for gathering and formally cataloguing lessons learned.
- Deliberate knowledge elicitation methods should be employed to capture experience as FCS is used in initial testing and experimentation.

Feedback

Feedback is the essential element to allow training to produce change in performance. It is more than a scorecard; rather, it is the essential ingredient for planning, productive use of lessons learned, and learning by sharing. Its purpose is to facilitate the learning process for the individual or group. Research observations and lessons learned concerning feedback fall into three categories.

Focused feedback

Feedback should be tailored to focus on key selected performance issues, not on an entire operation. This type of performance feedback will be difficult, if not impossible, in very large-scale exercises.

If the feedback is expected to cover the entire gamut of performances exhibited in an exercise, it will overwhelm the learner and result in no learning at all. Conversely, If feedback is properly held to focus on a selected set of objectives, limited or scaled exercises will be sufficient; large-scale exercises will embody lots of wasted effort and draw the focus to events rather than performance processes.

During analysis, the TDT identified the training objectives, and designed MOPs and MOEs to address them. Now, during conduct of the training, the feedback should be focused on the specific objectives for which the training was designed.

- Scaled exercises, with 5-8 objectives for a 2-4 hour block of performance, can be very effective in providing iterative practice and improvement.
- Feedback should be learner-centric and go beyond discussion of what was accomplished and the processes used. It should go on to a comparison with what the users intended to accomplish and the processes they intended to use, determining if they need to make changes to their processes, and describing how they intend to accommodate those changes in future operations.
- The structure supporting this kind of after action review, as well as the mechanisms for collecting the data and presenting the analyzed data as feedback, should be a standard part of any training component.
- Large-scale exercises are costly in many respects and frequently do not have training value for a significant portion of the participants. Scale the exercises to ensure that all participants are engaged.
- Large-scale exercises should be conducted only when individuals and UAs have been certified as proficient by means of scaled exercises and training.
- Use agent technologies to identify performance weaknesses and to provide automated coaching and feedback.
- Use the MOPs and MOEs to direct users to additional training.
- The TDT will also need to develop measures of performance, so that leaders can tell whether users have in fact met the standards and, if not, what they should do to further develop proficiency.
- For non-procedural tasks, using a coach or mentor for each individual should supplement, or even replace, the group-style after action review.

Timely feedback

With ET and computer-assisted training, the timing of feedback can be adjusted for maximum effectiveness. Sometimes, immediate corrective feedback is appropriate,

while at other times it makes better sense to allow the learner to explore and evaluate solutions with only intrinsic feedback.

If we do not adapt the timing of feedback to the training need, we will either fail to allow the learner to learn, or fail to correct incorrect performance.

The nature of the performance and the proficiency level of the training participants will be among the prime determinants of feedback timing.

- For novice participants, initial learning will be more effective with more frequent and directive feedback that shapes behavior along expert lines.
- For individuals and groups who have mastered the basics, exploration learning can be more effective, as long as intrinsic feedback occurs as appropriate.
- For tasks where there is no intrinsic feedback, or where that feedback can be misleading (e.g., not totally a result of the performance), extrinsic feedback should be provided.
- Withholding feedback so users learn from their mistakes should only occur in training if there is no feedback, intrinsic or extrinsic, in operational settings.
- During exercises, short informal performance feedback sessions can help learners to consolidate lessons learned and recognize cues to appropriate performance. Whether this is a programming chore or an O/C chore, tools will be needed to speed up the process.
- Performance feedback after an exercise is completed should occur with as little elapsed time as possible. Again, whether this is a programming chore or an O/C chore, tools to speed up the process will be needed.
- Real-time feedback should be a selectable feature.

Tailored feedback

Tailorable feedback will be a useful feature. With the right tools, the feedback can be customized to show exactly why particular things happened, to focus on one slice of the training audience, or (most simply) to flag events and viewpoints to be shown later.

There is no reason to present feedback as "one size fits all" – the technology will allow customization, and our knowledge of individual differences and cognitive load enables us to design appropriate options.

Different users have different preferences for how the feedback is presented, and allowing them to customize (within limits) increases the probability that they will pay attention to – and use – the information.

- Make it easy for commanders, users, and trainers to customize feedback by providing intuitively understandable tools, performance support on how to use the tools, filters, masks, templates, and wizards to assist them in finding the appropriate information.
- The tools should enable them to
    - customize feedback formats to match personal preferences.
    - look at samples of various feedback outputs.
    - adapt amount of feedback and presentation to training needs
    - flag events and viewpoints.
- Designate tools appropriate for before-during-after the exercise.
- Incorporate safeguards to prevent displays of misleading information or presentation.

Performance Support Systems

By definition, a performance support system (PSS) is a system that provides on-demand access to information, guidance, advice and assistance, training, and tools to enable high-level job performance with a minimum of support from other people. For *electronic* PSS, we add the qualifier that it is an *integrated computer-based system*. The primary function is to provide information or assistance to soldiers and teams in performing a broad range of tasks quickly and completely while minimizing sensory, cognitive, and physical demands. Research observations on this topic focus on four specific uses of performance support capabilities.

Information management and support

One of the most obvious uses of a PSS is to simplify the information flow.

The users needs have to be at the center of the PSS design, so that the tools and reports actually support the user.

The PSS, embedded as an element of the FCS software, will have several roles in information management to assist the user:

- Reach: In some cases, information should be readily available on user demand with an intuitive and reliable search engine. Other information should be offered without any overt user action. Certain information should be automatically posted to a central repository.
- Source fusion: The PSS should be designed to examine, analyze, and assess information from a variety of sources, in order to report highly reliable and accurate information.
- Knowledge management: Users should have the opportunity and support (in terms of agents and tools) for constructing and sharing knowledge, both in training and in operations.
- Some Objective Force performance needs are not fully addressable through training, requiring some other form of support to enable performance. For example, a prompt for a next step in performing a task may be far more effective and efficient than remedial training.

Feedback

The PSS should seamlessly support both training and performance. The SDT, as it designs software to capture and present data for training, must also explore the utility of feedback during rehearsals, concept exploration experimentation, and actual operations.

Although the same tools and feedback that are available for training can also be available for non-training situations, users must retain the option to tailor the feedback to match their roles, personal preferences, and the situation.

Operational presentations of feedback will *not* be the same as training presentations, even though they are derived from the same data collection protocols.

- Ensure operational feedback presentations are informative, not instructional.
- The tools for customizing information and feedback presentations must be intuitively understandable *(see Feedback)*.
- The capability to sharply reduce or even suppress feedback must be an option.
- Users must be able to turn "training opportunities" off during operations.

Operator surrogate or backup

The PSS can itself perform certain operator tasks or back-up operators as they perform.

If careful analysis of expert performance and information requirements forms the basis for designing the PSS, it can serve as an expert system to support operators or even take over certain tasks for them.

For example:

- Monitoring: A significant portion of the operator's time and effort will involve monitoring automated systems. The PSS can assist in monitoring by attending to selected information requirements or threshold conditions.
- Vigilance: Closely related to the requirement to monitor will be the need to stay alert. The PSS can be designed with features that change in simple ways periodically, which has been shown as a way to remind the operator to attend to the displays and information.
- Job performance aids: Simple procedures can be annotated and be available either automatically or on demand. Such approaches have been shown to reduce errors and performance time.

Training mechanism

The PSS information management capability and integration with the global network can easily be programmed to support training.

In as many ways as possible, the training role within FCS should mirror the performance environment, and the PSS can help do that.

Recently, an initial set of guidelines was prepared that, if followed, would lead to a more functional ET and electronic performance support system (EPSS) capability (outlined in Appendix D, sections D.23 and D.24).

- As the FCS is further developed, the initial guidelines need to be revised and expanded to keep up with current capabilities.
- If the PSS can provide real-time information on a situation, it can also generate scenario-specific information to drive training or rehearsals.
- The PSS, integrated with the training management system, should be programmed to adapt scenarios "on the fly" to match user readiness and training needs.

System Acquisition and Related Early Decisions

The FCS team has taken the position that training plans and system plans need to run on parallel and frequently touching paths, and that doctrine and tactics, techniques, and procedures (TTP) will be formulated while FCS is still in the design and early development stages. The observations in this section may be already reflected in the current approach. They are nonetheless presented here to reinforce the decisions and courses of action that the FCS team is already espousing.

Early collaboration

Early collaboration between system designers and training designers is essential to ensure that individual, crew, and collective training requirements are addressed.

Bringing doctrine developers and training development teams on board after a system design is set eliminates the flexibility required to maximize the potential capability of the system.

The advantages of early collaboration are compelling:

- When systems cannot fully support training and workarounds are required, early collaboration can produce intelligent and valuable workarounds rather than those that negatively impact training.
- Permanent, formal, and continuing early collaboration can be valuable in ensuring consideration of manpower and personnel integration (MANPRINT) aspects and integration of concept exploration.
- Early collaboration can shorten the time for training program development and integration into unit training plans and provides valuable feedback to system designers.

Planning ahead

Early collaboration is easier said than done. Planning how to bring all participants to the table to share ideas, plans, activities, concerns, and problems needs to be addressed even earlier than the early collaboration itself.

Early collaboration is not going to happen without concrete plans for how to accomplish it.

- The FCS team needs a template against which training and system development proposals will be judged to ensure integration among individual, self-development, and unit training.

Soldier-in-the-loop

Modeling and simulation are useful and valuable for concept development – they allow for multiple examinations of an issue under various conditions, with carefully standardized control of external variables. But at some point, soldiers must also be involved in the examination.

Until we can perfectly model the soldier, we need to use real soldiers in conjunction with system simulations.

The soldier-in-the-loop approach remains essential for, at a minimum:

- Proofing of MANPRINT design considerations.
- Developing and confirming the effectiveness of system and non-system training devices.
- Developing and proofing crew and unit TTPs.

Doctrine development

It is essential that doctrine and training be fielded at the same time as the systems.

An Objective Force and FCS without doctrine, even for a short period of time, will have nothing to train, no standards for performance, and little chance of being a potent force in the full spectrum of operations.

This should go without saying, but it didn't.

- Address concept of fighting doctrine early in acquisition process.
- Use modeling and simulators/simulations to first push doctrinal envelope then proof fighting doctrine.
- Ensure that doctrine development positions are filled by personnel with experience in digital, conventional, and back-up operations.

System Characteristics and Features

Much of the research performed over the past decade has addressed the characteristics of digital or information systems. Those observations are largely as relevant today for FCS as they were for the emerging forerunners of FCS. General observations about the characteristics needed for the FCS have been organized into seven topic areas.

Growth potential

Design and development of FCS constitute a sort of "living" process that will never stop changing or growing. Technology not only permits frequent upgrades, but demands the upgrades by virtue of its own fast pace of change.

If FCS is designed and built to exploit only current and near-term potential, it will be obsolete before it is fielded.

As design decisions are made, they need to consider not only the best that inventors and programmers can offer today, but also the "hooks" for what the future will offer *(see Big Picture)*.

- Design all hardware, software, and otherware for growth and reconfiguration.
- Use modular software to support rapid reconfiguration.
- Make iterative refinements based on soldier-in-the-loop testing to identify reconfiguration requirements.

Integration

The FCS is conceived as an "integrated" system – the concept is laudable and must apply to more than just the hardware and software found on one vehicle.

If integration as a goal is not applied to multiple systems, users, and functions, the system of systems will never achieve the envisioned potential.

Integration needs to be designed in, not jury-rigged after the fact.

- System designers must devise ways to integrate exercise support, training management, automated measurement, and performance support.
- Command and control systems should be integrated across echelons, platforms, and "players" (human, semi-automated, robotic).

Reliability

Reliability is always a goal, but it is even more necessary with high tech systems that cannot be repaired with duct tape and pantyhose (chewing gum, soap, etc.).

Soldiers will lose trust in nonreliable systems with lightning speed and will never quite recover.

One obvious solution is ultra-reliable systems. Other actions must also be taken:

- Manage user expectations concerning reliability and timelines.
- Provide training on back-up tasks as well as on troubleshooting and corrective actions.
- Communicate clearly any upgrades that are made.
- Make upgrade transitions painless by testing the upgrade process thoroughly and providing support.

Training support

Embedded training is going to be the primary mode of training, and the command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) network will be the backbone of training as well as operations. The FCS capabilities have to include training support as a nonnegotiable requirement.

To see FCS as a weapon system (of systems) that also supports training is no better than seeing it as a training device that also shoots – both functions are essential.

The TDT and SDT will need to work collaboratively as early as possible to ensure that user-training needs are as well supported, as are user operational requirements.

- Automation must be exploited to support feedback sessions (see Appendix D, section D.25 for summaries of strategies for automated feedback sessions).
- The tools for customizing training exercises and feedback should be integrated into the training subsystem.
- Capabilities to update training materials must be integrated and the process should be effortless for users; it should not be transparent: Users should be told when updates are posted, and the nature of the update should be described.
- Training management features should include training delivery (support for preparation and implementation activities and streaming of training scenarios), monitoring training-in-progress to provide feedback, tracking training progress for individuals and units, and generating training plans to ensure continuous improvement.

Presentation features

The TDT and SDT need to work together beginning with the first training design decisions, to make the presentations appeal to the audience.

If training is presented only with linear, passive formats, learners will not stay engaged and will not retain the information.

There are some specific features of computer-based training (including ET) that have been shown to be effective:

- Use multimedia previews that are accurate, colorful, concise, and mentally stimulating to facilitate immersion.
- Make the presentations intuitively understandable. If detailed explanations are required for users to understand the purpose of a presentation (whether feedback, information management, or PSS), the system will be of little or no value to users.
- Leaders must be able to perceive immediately and understand unequivocally what they are seeing on their screen (e.g., aggregated v. disaggregated unit icons, friendly v. threat forces).
- The tactical display and its controls should perceptually reflect the task and subtask structure of a user's hierarchical perception of task requirements. The key to mastery of a complex task is in the immediate perceptual processes where the task is structured.
- Build the system with commands with specific names to support retention.
- For initial skill acquisition, use direct manipulation or windows-like approach rather than command-based.

- Incorporate instructional principles such as advance organizers, metaphors, rehearsals, and framing (described in Appendix D, section D.26).
- Create training with a focus on pattern recognition for situations.
- Screens should be designed to be similar to what soldiers are used to – "common look, common feel" should be universal, not exclusive within the Army.

However:

- Don't reject traditional job aids (paper-based). Users in some situations may want something "always on top."

Workload management

Technological advances rarely simplify jobs without also increasing complexity, as well as cognitive and sensory load.

If results of job and task analysis in simulation are not fed back to system design and job design, performance of UA soldiers could quickly be degraded due to work overload.

The management of soldier workload must be addressed in terms of various aspects of their jobs:

- Control of robotic and semi-autonomous entities is affected by such variables as the design of the interface, attentional resources, the number and type of concurrent tasks, the reliability of the systems, and environmental stressors, all of which must be monitored and managed.
- Deliberate procedures are needed to control the analysis and flow of digital data. Not only should information management be a primary topic in the standard operating procedure (SOP), but the FCS itself should be able to perform some of the SOP requirements and tasks. This assumes, of course, that the SOP/TTP for FCS UAs will be standardized to some noticeable degree.
- Both information amount and information relevance significantly impact the ability of soldiers to manage information received from C2 systems, and must be monitored and controlled.

User needs

The design of a C2 system must be based on the information demands and needs of users.

For the designers of FCS to produce a system that meets user needs, they need to pay attention to user needs and not get trapped into a technology-driven design process.

Designers need to review and work with recommendations from users to identify and meet battle command information requirements.

- Battle lab experiments have already provided user recommendations to serve as a starting point (see Appendix D, section D.27).
- Instead of a shotgun blast of information, commanders want information sent to them tailored, so they only receive what they need.
- Instead of raw intelligence, commanders expect grounded intelligence summaries that explain the enemy's intent. The digital [and FCS] commander's questions are more specific than his analog counterpart's.

- Commanders' priority information request (PIRs) are more focused when the systems exist to support them. As a result of information sharing, technology makes PIRs available at all levels.

Performance Improvement – Factors Beyond Training

Despite what the training contractors would have you believe, it isn't all about training. But it isn't all about the systems, either. Some of the threats to success are presented here.

Personnel challenges

Training cannot be the answer for all of the UA performance hopes and dreams.

If we provide brilliant training but don't address the rest of the picture, we will fail.

It is vital that the Army conduct analyses to determine role of training, selection and classification, and personnel assignments in the Objective Force UAs. Related non-training personnel actions include:

- Upgrading the personnel selection process, classification and promotion procedures, and utilization and assignment policies. We cannot simply ask soldiers to perform a broader range of skills while at the same time specifying that no increase in aptitudes and experience should be required to operate, maintain, or sustain the FCS UA.
- Taking another hard look at the notion that FCS UA soldiers will be multi-skilled, a keystone for the UA, especially as it operates in concert with legacy and Stryker forces.
- Examining leader development, which depends on the formation of in-depth expertise across a range of command-related areas, both vertical and horizontal. Without major changes in the way officers and non-commissioned officers (NCOs) are recruited, selected, trained, and mentored, it is highly unlikely that seasoned adaptive leaders can be produced easily and rapidly.

Human factors challenges

The new FCS capabilities will also introduce problematic situations that did not arise in the older legacy systems, and somewhere, somehow, the FCS team needs to address the issues. Such threats to excellence include:

- Information overload and resultant fatigue.
- Overcontrol of subordinates.
- Vulnerability to countermeasures.
- Incompatible technologies among coalition forces.
- Failure to adapt organization structure to new doctrine and procedures.

Additionally:

- The suggestion that we reduce manpower requirements without reducing combat effectiveness through use of smaller crews augmented by new technology may be naive. Our experience is that information technology (IT) can flatten organizational structure, reduce the need for centralized operations, and change the nature of jobs, sometimes making them more complex, but rarely does it reduce workloads. Instead, the workload is shifted and the nature of work loading is changed. Low skill tasks are automated, leaving soldiers to perform more complex tasks that cannot be easily automated. In the end, there are limited degrees of freedom: To have smaller teams, we will need increased aptitude and/or training.

Formal information sharing

As FCS enters the Army and units begin to develop TTP, information flow will be critical if we want to continue to share observations and lessons learned.

If we cannot devise and maintain an information sharing mechanism, progress toward readiness will be handicapped.

There are a number of entities that need to be nodes in and/or users of the information network.

- Proponent interaction is essential, to interface and share lessons learned on important aspects of training, how-to-fight doctrine, and back-up requirements.
- Permanent working groups among proponents, as well as joint and coalition groups need to be formed to focus on specific shared issues.
- As UAs are forming and learning, crosstalk and feedback among them is needed to formulate TTP.
- Not only should we continue to review lessons learned from leaders, we should be prepared to obtain the same type of information from Objective Force leaders. A summary of key findings distilled from leaders' insights on Force XXI transition was prepared – it is shown in Appendix D, section D.28.
- We need to institutionalize and formalize linkages between early-fielding units and later fielding units, and between units and proponents.

Miscellaneous

Having categorized the vast majority of "nuggets" from the literature and interviews into topics and subtopics, there remained a few that didn't fit anywhere else but were too good to just discard. They include the following:

- The Army needs to be a "learning organization" and needs to encourage creative thinking, balanced with standardized ways of doing things.
- On the topic of span of control: Commander and staff at corps, division, and brigade (and most company level) report more severe negative impact from the complexity of the environment and absence of assistance from their organizational structure than from an increased span of control.
- Additionally, lack of habitual relationship with supported units seemed to have at least as much negative impact as the number of subordinate units.
- A consistent finding for force projection and SASO stressed the importance of avoiding ad hoc structures. The Joint Task Force (JTF) should be built on an existing DoD unit, and be augmented as necessary by specially trained cells.
- As military strategists and tacticians ponder and plot unit organizational structures, they will also need to explicitly define the role of the homestation operations center (HSOC) in training, and the relationship between the HSOC and forward deployed units.
- If any training is to be effective, there will need to be a strong commitment by senior leaders to protect training time and resources.

Appendix A. Definitions of Acronyms and Jargon

Acronyms

A3ARM	advanced after action review media
AAR	after action review
AC	active component
ADTP	Advanced Distributed Training Program
AFRU	Armored Forces Research Unit
AIT	advanced individual training
ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
ARL	Army Research Laboratory
ARTEP	Army Training and Evaluation Program
ATESC	advanced tactical engagement simulation concepts
ATIA	Army Training Information Architecture
BC	Battle Captain
BCT	basic combat training
BF	battlefield function
BLUFOR	blue forces
BOS	battlefield operating system
C2	command and control
C4I	command, control, communications, computer, and intelligence
C4ISR	command, control, communications, computers, intelligence, surveillance and reconnaissance
CALL	Center for Army Lessons Learned
CCTT	Close Combat Tactical Trainer
CEP	concept experimentation program
COP	communities of practice
CRIOT	cognitive requirements for information operations training
CTC	Combat Training Center
CVC	combat vehicle command
DL	distance learning
EPSS	electronic performance support system
ET	embedded training
FBCB2	future battle command brigade and below
FCS	Future Combat Systems
FRAGO	fragmentary orders
FSO	fire support officer
HSOC	homestation operations center

IDEF0	Integrated Definition
IET	initial entry training
IFRU	Infantry Forces Research Unit
IPT	integrated process team
IS	instrumentation system
ISD	Instructional Systems Design
IT	information technology
JIM	joint, interagency, and multi-national
JTF	Joint Task Force
LMS	learning management system
LOS	line-of-sight
LSI	Lead Systems Integrator
MANPRINT	manpower and personnel integration
METL	mission essential task list
METT-TC	mission, enemy, terrain, troops, time, and civilian considerations
MOE	measure of effectiveness
MOP	measure of performance
MOS	military occupational specialty
MSS	multi-skilled soldier
MTOE	modified tables of organization and equipment
MTP	Mission Training Plan
NBC	nuclear/biological/chemical
NCO	non-commissioned officer
NET	new equipment training
NLOS	non line-of-sight
O/C	observer/controller
OIS	objective instrumentation system
OPFOR	opposing force
OPTEMPO	operational tempo
PDA	personal digital assistant
PIR	priority information request
POI	program of instruction
PSS	performance support system
q.v.	quod vide, meaning to go look it up
R&D	research & development
RC	reserve component
S2	intelligence officer
S3	operations officer
SA	situational awareness

SAIC	Science Applications International Corporation
SAT	Systems Approach to Training
SDT	system development team
SIMNET	simulation networking
SME	subject matter expert
SOP	standard operating procedures
SASO	stability operations and support operations
SOW	Statement of Work
SPA	Staff Performance Analysis
SSRU	Simulation Systems Research Unit
STRAP	system training plan
STRIVE	Satisfying Training Requirements in Virtual Environments
TAAF-X	Training Analysis and Feedback Center of Excellence
TADSS	training aids, devices, simulators, and simulations
TAF	tactical analysis facility
TDT	training design team
TES	tactical engagement simulation
TRADOC	U.S. Army Training and Doctrine Command
TSC	training support code
TSP	training support package
TTP	tactics, techniques, and procedures
UA	Unit of Action
UAMBL	Unit of Action Mounted Battlespace Laboratory
UTMS	unit training management system
VPN	virtual private network
XO	Executive Officer

Jargon

Access *or* accessibility: Includes downloading, working on-line, logging in to a discussion group, reading – however the user and the component are supposed to connect.

Aggregated: With tactical displays, refers to how entities (units, soldiers, etc.) are represented, and could be, for example, one icon or symbol per vehicle, per squad, per company, or per UA. When the entities are "rolled up" they are said to aggregate; when broken out, they are disaggregated. The tradeoffs are in terms of information precision vs. big picture displays of information.

Asynchronous: In distributed learning arenas, communications among students and instructors that involve some delay, such as by means of email where the receiver retrieves messages on his/her own timeline and can respond later.

Automaticity: In task performance, the quality of being able to perform complex activities, comprising a long series of steps or motions, without conscious attention to the sequence

or process. Common (non-military) examples include using a keyboard, playing piano, driving a car.

A-way: As opposed *the [only] way*, indicates that the subject training or process will work but is not necessarily the only way to do the training or process.

Behaviorist: Characterizing behaviorism theories of instruction, where objectives are determined by analysts before training is provided and are the focal point for developing the instructional materials; training participants learn how to execute tactical actions; and AARs are led by the instructors. See also *Constructivist.*

Cognitive strategies: Ways of learning (and therefore of instructing) that reflect the way individuals process information. A key feature of these strategies is that the learner is an active participant in the learning process.

Component: See *training component.*

Concept exploration: The use of simulation, ranging from low-fidelity enactments to high fidelity technology-supported exercises or live exercises, to try out and refine ideas on organizations, operations, doctrine, etc.

Constructivist: Characterizing constructivism theories of instruction, where instructional objectives emerge from decisions made by the training participants; there are authentic instructional conditions; the participants develop an understanding of the principles of tactics; and AARs are led by the students.

Disaggregated: See *aggregated.*

Distributed training: Training of teams, small groups, or units where the participants are not co-located. They may be in their own vehicles or tactical locations, or may even be at dispersed learning centers or posts.

Dyad/triad/quadad: Groups of two, three, or four or more (quadad being a term invented to mean "four or more") who are designated as the training audience for targeted exercises.

Enabling Skills: Those skills that are more basic, learned early (or earlier), and may not of themselves be important but are important as the building blocks for more complex critical or terminal tasks (*see terminal skills*).

Enabling objectives: Training objectives for enabling skills (*q.v.*).

Extrinsic feedback: Feedback that occurs because a device that is appended or external to the operational system is triggered, or because a designated O/C detects a particular behavior.

Force XXI: During the years after the end of the cold war and into the new century, the Army has been focused on change. Training and Doctrine Command was charged with the mission of transforming the tactical Army. The TRADOC focused on doing that across all the Army's mission areas: doctrine, training, leader development, equipment, and force design, ensuring quality in each area. The process of change is called Force XXI.

Integrated Definition (IDEF0) system analysis: IDEF0 modeling is used to analyze the functions a system performs and to record the mechanism (or means) by which these functions are done. The IDEF0 modeling is composed of a hierarchical series of diagrams that gradually display increasing levels of detail describing functions and their interface with the context of a system.

Intrinsic feedback: Feedback that occurs within a system or environment as the natural outcome of a particular action; not delivered by an O/C or generated by some appended system.

Journeyman: More skilled than novice or apprentice, but not yet expert; able to perform most tasks with minimal supervision.

MANPRINT: Generally, a set of standards and guidelines for systems that defines the minimal requirements for manpower and personnel, including training and ergonomics.

Mission rehearsal: A relatively high-fidelity and realistic opportunity to practice and improve methods for a specific operation under specific conditions.

Multi-skilled soldiers (MSS): The MSS concept is an important part of the UA requirements discussions. For the UA, the MSS is

(1) additionally skilled with cross-training from the institution, to provide greater depth and redundancy of specific skill sets within the UA;

(2) generic in terms of MOS non-specialization, with focus on principles that would generalize;

(3) adaptable, exhibiting creative and problem-solving qualities attributed to the emerging notion of the adaptive leader, with training focused on mindset of adaptability, self-education, and problem-solving;

(4) perpetually learning, must be trained and motivated to deepen and broaden the skills they acquire in IET through never-ending self-education, largely through distributed training and DL; requires significant professional development incentives, resources, and mentoring.

Performance objectives: Statements and descriptions that focus first on what should be accomplished, and then move on to describe suggested ways to do it. Where tasks tend to be procedural, performance objectives describe the desired end state and only assist the user on performance steps peripherally.

Procedural training: Training in how to perform tasks that have set steps and sequences.

Scenario nesting: A method for developing the scenarios underlying training exercises where different individuals, teams, and units at multiple echelons all work within a common underlying tactical scenario. Each user or user group sees only the appropriate slice of the larger scenario.

SIMNET: Simulation Networking, a virtual simulation technology used principally in training mounted maneuver forces and mounted infantry.

Structured training: Training that is focused on specific training objectives in a deliberately-constructed training package, and that takes full advantage of instructional design principles and available simulation capabilities to provide training that is both efficient and effective.

Synchronous: In distributed learning arenas, communications that occur in real time among students and instructors; direct interactions, whether by voice or instant messaging-like methods.

Technology insertion: The situation in the design and develop cycle for a system (any system – training, hardware, software, etc.) in which a technology (new or not previously included)

is deemed important and useful enough that the already-developed system will be adapted to accommodate use of the new technology.

Terminal objectives: Training objectives for terminal skills.

Terminal skills: Those skills that are the end state for a block of training, the culmination and *raison d'etre* for the training of a set of enabling skills (*see enabling skills*).

Training component: Information *items* that make up the TSP, as opposed to the content of the TSP and its components.

Training domain: The complete set of tasks, conditions, and standards that should be the content of training; may be restricted to a particular audience, force type, etc.

Training support package: A complete, exportable package integrating training products, materials, and/or information necessary to training one or more critical [collective/individual] tasks (definition from TRADOC Reg 350-70, *Systems Approach to Training Management, Processes, and Products* [Department of the Army, 1999]).

Unit of Action: The command and control unit of the Objective Force, roughly equivalent to brigade-level in the Legacy Force.

Workarounds: Deliberate and planned methods for representing elements or activities or the outcomes of activities in simulation environments when they cannot be presented directly.

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Appendix C. Matrix of Topics and References

In the matrix below, each of the reviewed articles and reports is shown with the topics that it addresses. Readers who want more information on particular topics can thus limit their search to the most relevant sources. References that are **bolded** are particularly relevant, and are also summarized in Appendix D.

REFERENCES (See Appendix B for full citation)	Theme	Strategy	Analysis	Objectives	Design	Development	Implementation	Evaluation	Measurement	Feedback	PSS	Acquisition	Features	Nontraining	Research
Anderson et al. (2000)							X								
Andre et al. (1997)						X	X								
Atwood et al. (1991)									X						
Atwood et al. (1994)					X		X								
Barnett & Holmquist (2001)											X		X		X
Barnett et al. (2001)				X											
Bonk & Wisher (2000)					X						X				
Brown et al. (1998)							X			X					
Burnside (1990)						X									
Campbell & Deter (1997)			X		X	X	X	X							
Campbell & Holden (2001)		X		X	X		X								
Campbell et al. (1995)			X		X	X	X	X							
Campbell et al. (1997)			X		X	X		X		X					X
Campbell et al. (2000)		X				X	X								
Campbell, Deter, et al. (1999)	X				X		X								
Campbell, Ford, et al. (1998)					X	X		X							
Campbell, Graves, et al. (1998)	X		X			X				X					
Campbell, Pratt, et al. (1999)						X	X								
Clagg et al. (1999)			X		X	X								X	X
Collins & Throne (1996)							X								
Cox et al. (2002)				X										X	
Deatz & Campbell (2001)			X		X	X									
Deatz et al. (1998)					X										
Deatz et al. (2000)					X					X	X				
Department of the Army (1999)			X		X	X	X	X							
Dierksmeier et al. (1999)		X		X		X	X				X	X			
Dudley et al. (2001)													X		
Elliott et al. (1996)					X										
Endsley et al. (2000)									X						
Fallesen et al. (1992)				X											
Finley et al. (1996)					X										
Finley et al. (2000)		X		X	X	X	X		X						X
Flynn et al. (1998)												X			
Ford, J. P. et al. (1997)									X						
Ford, J. P. et al. (1998)				X									X	X	
Ford, L. A. et al. (1998)		X		X								X		X	X
Gossman et al. (1999)						X									
Gossman et al. (2001)					X		X								
Gossman et al. (2002)		X				X				X	X		X		
Graham & Matthews (1999)				X	X									X	

REFERENCES (See Appendix B for full citation)	Theme	Strategy	Analysis	Objectives	Design	Development	Implementation	Evaluation	Measurement	Feedback	PSS	Acquisition	Features	Nontraining	Research
Graves & Myers (1997)									X						
Graves et al. (1997)			X		X		X	X		X	X				
Graves et al. (1999)					**X**	**X**	**X**						**X**		**X**
Greess (1994)									X				X		
Heiden (1994)					X										
Hoffman (1997a)					X		X								
Hoffman (1997b)					X										
Hoffman et al. (1995)					X										X
Holden et al. (2001)									X	X	X		X		
Holland & Wisher (1990)							X								
Jenkins et al. (1999)					**X**										
Jones (1999)				X	X		X								
Kern et al. (1994)					X										
Koger et al. (1996)							X								
Koger et al. (1998)				X	X		X			X					
LaJoie & Sterling (1999)				X											
Leibrecht et al. (1993)						X			X				X		
Leibrecht et al. (2002)														**X**	**X**
Lickteig & Collins (1995)									X						X
Lickteig & Emery (1994)													X		
Lickteig & Quinkert (2001)							X		X				X		
Lickteig & Throne (1999)													X		
Lickteig et al. (1998)													**X**		
Lickteig et al. (2002)		X			X								X		
Lussier et al. (2000)							X								
Meliza (1996)										X					
Meliza (in press)				**X**					**X**						
Meliza & Knerr (1991)						X									
Morrison & Hammon (2000)								**X**							
Moses (2001)															X
Nelson & Akman (2002)		**X**		**X**											
Olmstead (1992)			**X**						**X**						
Quensel et al. (1999)			**X**		**X**				**X**				**X**		
Salter & Black (1998)		X		X									X	X	
Sanders (1999)											X		X		
Sanders (2001)				**X**	**X**										
Sanders & Burnside (2001)							X								
Shlechter & Finley (2000)		X	X		X	X	X	X					X	X	
Shlechter et al. (1987)		X													
Shlechter et al. (1995)					X										
Smith et al. (2002)		X													
Sterling & Quinkert (1998)				X	X	X									
Sticha et al. (2002)						**X**		**X**							**X**
Sulzen (1996)							X								
Throne & Burnside (2003)											**X**				
Throne & Lickteig (1997)					X								X		
Throne et al. (1999)					X										
Throne et al. (2000)									X	X					

REFERENCES (See Appendix B for full citation)	Theme	Strategy	Analysis	Objectives	Design	Development	Implementation	Evaluation	Measurement	Feedback	PSS	Acquisition	Features	Nontraining	Research
Wampler & Livingston (1998)			X								X				
Wigginton & O'Brien (1991)			X									X			
Wisher & Kincaid (1989)											X				
Wisher et al. (1999)								X							

Appendix D. Explication of Selected Methods and Findings

In the following pages, 24 methods, processes, and summaries of findings are presented. The presentations are brief, providing only outlines of the information. They are included to give the reader basic information on what direction and guidance can be found in selected reports and publications. These summaries are not intended to give complete guidance or data, but rather to let the reader know what to expect when the full reference is consulted.

D.1 Proposed Roadmap for Multi-Skilled Soldier (MSS) Achievement

In order to transform the current soldier to a multi-skilled soldier, the Army is faced with making a series of major decisions and initiating a set of key planning and implementing actions. This set of decisions and actions is captured in an MSS Roadmap (Nelson & Akman, 2002), which indicates pivotal steps required in the short-, near- and long-term to emplace a functioning MSS system by 2008. The Roadmap actions are associated with three umbrella organizational groupings: the Army Leadership, the Personnel Community, and the Training Community. In the context of the Roadmap, the Training Community refers primarily to U.S. Army Training and Doctrine Command (TRADOC) Headquarters (East and West), the training centers, and the subordinate system of branch and functional schools. That portion of the Roadmap, taken from Nelson and Akman, is outlined below.

Near-Term (2002-2004)	Mid-Term (2004-2005)	Long-Term (2006-2008)
	Training Policy Actions	
• Develop concept for future training paradigm (and scope). • Determine changes to leadership development paradigm. • Consider impact on RC. • Determine future role of branches. • Determine changes to training base. • Determine master transition concept for Training Community.	• Begin implementing master transition plan in earnest. • Adjust training base as planned. • Review Objective Force requirements. • Adjust master plan as required.	• Prepare Army as a whole for training changes. • Publish supporting training documents.
	Training Planning and Development Actions	
• Redesign basic combat training (BCT) and advanced individual training (AIT). • Determine additional skill modules. • Design unit-of-assignment training. • Develop DL support concept. • Determine transition resources. • Develop construction plan. • Develop re-stationing plan. • Develop transition plan for the Training Community. • Develop plan to acquire training developers in sufficient numbers. • Develop DL support plan. • Test DL methodology. • Conduct behavioral research in selected supporting topics.	• Program transition resources. • Start required construction. • Develop supporting DL courses. • Start implementing transition plan for training base. • Test new training paradigm courses with control groups. • Develop initial entry base courses. • Develop additional skill modules. • Develop unit of assignment courses. • Develop DL courses. • Develop plan to modify leadership courses. • Increase number of training developers. • Continue behavioral research.	• Position training personnel, materials, and equipment for full-scale execution. • Refine plans for eventual NCO training of MSS. • Fully resource training base for execution. • Complete required construction. • Expand/test DL courses and methodology. • Adjust leadership courses to prepare for MSS. • Continue behavioral research.
	Transition Training Actions	
• Develop Training transition plan.	• Prepare initial training base cadre. • Set up required courses.	• Test all courses with larger and larger control groups.

Reference:

Nelson, J. T., II & Akman, A. (2002). *The Multi-Skilled Soldier Concept: Considerations for Army Implementation* (ARI SR 2002-06). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.2 Development of Structured Simulation-Based Training Programs

One of the earliest training development efforts for simulation networking (SIMNET) was also one of the earliest examples of large-scale development of structured training. Campbell, Campbell, Sanders, Flynn, and Myers (1995) assembled the lessons learned and numerous examples from the project into a methodology, based on the ISD method, for developing the program, associated TSPs, and training guidance for exercise observers and support personnel. A separate section of the methodology report addresses transitioning existing training for new requirements. Numerous job aids, in the form of developer worksheets, are also included. The development process for the training itself is described briefly below; the process for developing support personnel guidance is outlined in the following annex.

Phase	Activities	Evaluation
1. Document Initial Decisions	Decision areas: • Target training audience. • Training context – mission type, enemy, terrain/locale, unit type. • Simulation technology. • Other, including exercise time, trainer resources, entry points...	Proponent review
2. Design Training Objectives	2.1 Identify task sources, tasks, and standards. 2.2 Refine task list according to simulation support. 2.3 Select tasks that support the mission.	Proponent reviews; internal review
3. Design Scenario and Exercise Structure	3.1 Design the scenario – mission and higher echelon mission. 3.2 Prepare exercise context and specifications, including sequencing and table structures. 3.3 Outline events and build exercises.	Map exercise; simulation-controlled trials; pilot test with knowledgeable personnel
4. Develop TSP	4.1 Prepare TSP components for exercise support and O/Cs. 4.2 Prepare TSP components for the unit in training.	Tryouts (pilot tests and trials), expert reviews

Reference:

Campbell, C. H., Campbell, R. C., Sanders, J. J., Flynn, M. R., & Myers, W. E. (1995). *Methodology for the Development of Structured Simulation-Based Training* (ARI RP 95-08). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.3 Expanded Procedure for Development of Structured Simulation-Based Training Programs

During construction of battalion staff exercises for Force XXI, Campbell and Deter (1997) updated and modified an earlier methodology (Campbell, Campbell, Sanders, Flynn, & Myers, 1995) to make it suitable for use in developing a broad range of exercises in live, virtual, or constructive simulation environments. The expanded guidance also contains additional examples of TSP components. The procedure is outlined below.

Phase	Activities	Evaluation
1. Document Initial Decisions	Decision areas: • Target training audience. • Training context – mission type, enemy, terrain/locale, unit type. • Simulation technology. • Other, including exercise time, trainer resources, and entry points.	Proponent review
2. Design Training Objectives	2.1 Identify task sources, tasks, and standards: 2.2 Refine task list according to simulation support. 2.3 Select tasks that support the mission.	Proponent reviews; internal review
3. Design Scenario and Exercise Structure	3.1 Design the scenario. 3.2 Prepare exercise context and specifications. 3.3 Outline events and build exercises.	Map exercise; simulation-controlled trials; pilot test with knowledgeable personnel
4. Develop TSP	4.1 Design TSP structure. 4.2 Prepare TSP materials.	Tryouts (pilot tests and trials), expert reviews

References:

Campbell, C. H. & Deter, D. E. (1997). *Guide to Development of Structured Simulation-Based Training Programs* (ARI RP 97-14). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Campbell, C. H., Campbell, R. C., Sanders, J. J., Flynn, M. R., & Myers, W. E. (1995). *Methodology for the Development of Structured Simulation-Based Training.* (ARI RP 95-08). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.4 Development of Small Group Exercises

In the process of developing 24 small group exercises, or vignettes, for brigade staff members, Campbell, Ford, Campbell, & Quinkert (1998) also delineated the procedure followed, which can be used in creating additional exercises. The procedure is a special application of the broader methodology found in Campbell and Deter (1997), which addresses development of structured training exercises in general. The report contains examples and explanations that specifically address the construction and evaluation of small group structured exercises. The procedure is outlined briefly below.

Phase	Activities	Evaluation
1. Prepare Initial Design	1.1 Document initial scope decisions. 1.2 Select vignette event and participants. 1.3 Outline vignette architecture.	Internal review, proponent review
2. Design Vignette Scenario	2.1 Analyze event context and participant performance requirements. 2.2 Determine vignette scope and primary participants. 2.3 Determine vignette inputs and methods for delivery. 2.4 Describe specifications of tactical products.	Proponent reviews; SME reviews and walkthroughs
3. Prepare Detailed Training Objectives	3.1 Identify sources for performance requirements and performance standards. 3.2 Draft specific vignette training objective and performance requirement statements. 3.3 Draft after action review (AAR) aids.	Internal reviews, proponent reviews
4. Develop TSP	4.1 Prepare TSP components. 4.2 Assemble the TSP. 4.3 Evaluate vignette and TSP.	Proponent review, tryouts (pilot tests and trials), expert reviews

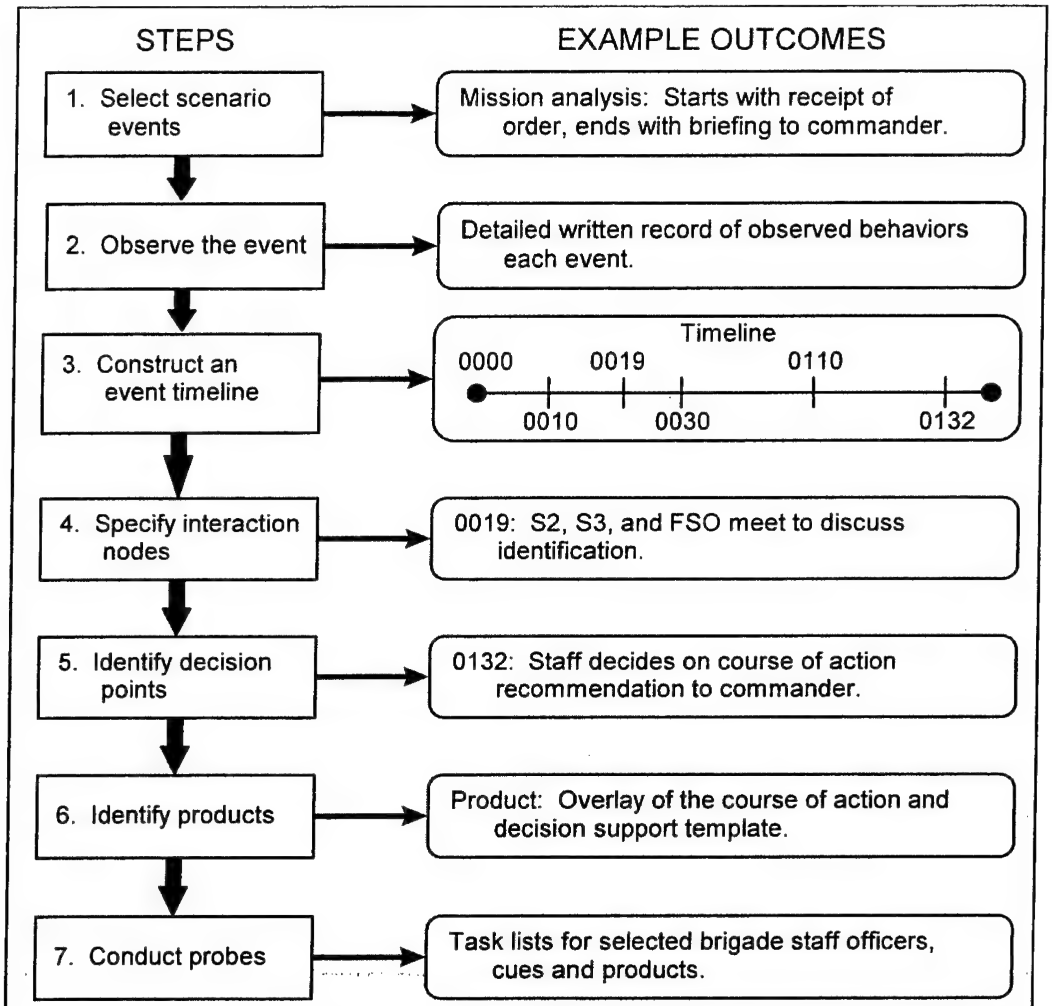
References:

Campbell, C. H., Ford, L. A., Campbell, R. C. & Quinkert, K. A. (1998). *A Procedure for Development of Structured Vignette Training Exercises for Small Groups* (ARI RP 98-37). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Campbell, C. H. & Deter, D. E. (1997). *Guide to Development of Structured Simulation-Based Training Programs* (ARI RP 97-14). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.5 The Staff Performance Analysis Process and Results

Campbell, Ford, Campbell, & Quinkert (1998) present a process for discovering staff tasks not included in standard doctrinal references. In the Staff Performance Analysis ([SPA], diagrammed below), project staff systematically explored the performance of brigade staff activities required in the conduct of the three selected missions. Activity exploration was conducted through mission enactment, or roleplay events, by SMEs in brigade operations, followed by introspective probing after mission enactment. Thus, both immediate and briefly delayed recollections of physical and cognitive processes served as the foundation of task identification. The SMEs identified and constructed staff products to be used in refining the scenario storyline and preparing the AAR structure and materials.



Note: S2 – Intelligence Officer; S3 – Operations Officer; FSO – Fire Support Officer

Reference:

Campbell, C. H., Ford, L. A., Campbell, R. C. & Quinkert, K. A. (1998). *A Procedure for Development of Structured Vignette Training Exercises for Small Groups* (ARI RP 98-37). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.6 Digital Skill Sets

The following table presents 22 digital skills divided into four basic categories (adapted from Table 5 in Barnett, Meliza, & McCluskey, 2001, p. 13). Barnett et al. identified these skills, which cut across specific digital systems and software versions, by reviewing available documentation on how digital systems were to be operated. Their report also provides a description of each skill and the source of the concept for each.

Digital Skill Categories	Skills
Network Skills	1. Prepare for, and recover from, system crashes or other periods of non-availability.
	2. Establish and check communications links and network connections.
	3. Protect network from operator error and malfunctions.
	4. Perform periodic checks of digital systems.
Basic Operator Skills	5. Prepare and update plans, reports, and other messages.
	6. Exchange data with external databases.
	7. Create, modify, and employ overlays, templates, and graphics.
Basic User Skills	8. Assess completeness of information on the tactical situation.
	9. Assess currency of information on the tactical situation.
	10. Assess completeness and clarity of planning products.
	11. Coordinate with others to acquire information.
	12. Identify situations where a physical terrain reconnaissance is required.
	13. Monitor changes in planning products.
Exploitation Skills	14. Maintain awareness of own unit relative to threats.
	15. Compare expected and actual status of friendly units.
	16. Maintain awareness of trigger events and events addressed by execution matrices.
	17. Use situational awareness data to move to a vehicle or control measure location.
	18. Use situational awareness data and terrain analysis tools to select routes and positions.
	19. Use situational awareness data to control unit movement and deconflict routes.
	20. Use situational awareness data and terrain analysis tools to predict contact variables and support battlefield operating system (BOS) integration.
	21. Monitor timing of planning activities.
	22. Define rehearsal objectives.

Reference:

Barnett, J. S., Meliza, L. L., & McCluskey, M. R. (2001). *Defining Digital Proficiency Measurement Targets for U.S. Army Units* (ARI TR 1117). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.7 Digitization Applied to Unit Performance Problems

The following table presents eight categories of unit performance problems and how they can be addressed, at least partially, through digitization (adapted from Table 4 in Barnett, Meliza, & McCluskey, 2001, p. 10). Barnett et al. also present over 200 specific problems that fall into these eight categories and whether improved battlefield visualization, increased operational tempo (OPTEMPO), or both will address each problem. In general, the benefits of digitization that are likely to address a problem in a category will also address other problems in the same category.

Problem Categories	Digitization Potential
Lack of awareness of some aspect of the tactical (friendly or threat) situation	Battlefield visualization (increased situational awareness).
Lack of synchronization (within or across BOSs) in terms of time, space, or activities	Battlefield visualization (increased situational awareness and wargaming tools) and increased OPTEMPO (sharing of evolving plan).
Lack of awareness of some aspect of the plan or lack of input to the plan by a BOS or sub-unit	Increased OPTEMPO (sharing of evolving plan).
Details missing from plan	Increased OPTEMPO (sharing of evolving plan).
Lack of understanding of the tactical situation	Battlefield visualization (increased situational awareness and wargaming tools).
Key elements of the plan produced late	Battlefield visualization (increased situational awareness) and increased OPTEMPO (sharing of evolving plan).
Inadequate mission preparation	Battlefield visualization (increased situational awareness) and increased OPTEMPO (sharing of evolving plan).
Unit is highly vulnerable or lacks lethality	Battlefield visualization (increased situational awareness and wargaming tools).

Reference:

Barnett, J. S., Meliza, L. L., & McCluskey, M. R. (2001). *Defining Digital Proficiency Measurement Targets for U.S. Army Units* (ARI TR 1117). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.8 Method for Analysis of Back-Up Requirements

Ford, Campbell, and Cobb (1998) discuss training issues associated with digitization, specifically those that address a need to train and maintain back-up skills along with digital skills. Their study investigated issues applicable to a wide range of digital applications and training conditions and examined individual and collective tasks that support tank operations. A summary of their method for analysis of digital and back-up requirements is provided below.

Define the digital performance domain	Delineate tasks in terms of digital or nondigital performance; types of tasks include – a. Individual tasks b. Leader tasks c. Crew tasks d. Platoon tasks e. Company/team tasks f. Battalion/task force tasks
Categorize performance type	Categories include – a. Communicate information – exchange of information b. Equipment operation – button-pushing procedures c. Gunnery – acquiring and destroying targets d. Maintenance (diagnostics only) – identification of vehicular faults e. Navigation and movement – locating a point or determining a course to a position and moving to that location f. Situational awareness – seeing and understanding battlefield information
Analyze back-up requirements	Identify documented tasks that can serve as back-up and those back-up requirements that have not yet been documented for – a. Individual tasks (1) Conventional (2) Workaround (3) Repair/replace system b. Leader, crew, and collective tasks

Reference:

Ford, L. A., Campbell, R. C., & Cobb, R. M. (1998). *Analysis of Emerging Digital and Back-up Training Requirement* (ARI SR 98-07). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.9 Training Objectives for Battalion and Brigade Sections and Leaders

Quensel et al. (1999), in developing training for brigade and battalion commanders and staffs, adapted work of Olmstead (1992) to compile training objectives focused on cognitive competencies, as described below.

Training Objective	Description
***Monitor* unit operations**	**Each section** actively seeks information about higher, adjacent, support, and subordinate units. **Each section** acquires information by listening to reports and asking for needed information.
***Process* information and messages**	**Each section** collates, transforms, and organizes information. **Each section** stores information on maps, situation boards, journals, and files. All information can be retrieved and used.
***Analyze/evaluate* information**	**Each section** attaches meaning (speculative or confirmed) to acquired information.
***Communicate* mission critical information**	**Each section** transmits information or intelligence to those who must make decisions about or act on it. This includes initial transmittal of sensed information; relaying; and disseminating throughout the staff, command posts, subordinate units, supporting units, and higher headquarters.
***Coordinate* information and intelligence**	**Each section** exchanges and discusses information and intelligence with others outside the section to clarify meaning and determine implications.
***Integrate* staff input**	The **Executive Officer (XO)/Battle Captain (BC)** aids the commander's battlefield awareness by: • combining information and intelligence from all staff sections, • putting information and intelligence into a useable format, and • passing information and intelligence to the commander. The **XO/BC** identifies areas requiring staff sections to combine efforts to support the commander's intent.
***Recommend* a course of action**	**XO/BC** and **staff sections** develop and analyze courses of action. **XO/BC** recommends a course of action to the commander.
***Disseminate* commander's decision**	The **staff** prepares and issues orders or fragmentary orders (FRAGOs) to inform units and staff of commander's decision.
***Synchronize* activities of units**	The **XO/BC** and **each section** monitor subordinate and supporting unit and BOS assets to ensure their efforts are aligned to execute the commander's intent or direction.
***Direct* assets to support commander's intent**	The **XO/BC** and **each section** track activities of BOS assets and intervene, if required, to ensure their activities support the commander's intent.

References:

Olmstead, J. A. (1992). *Battle Staff Integration* (IDA Paper P-2560). Alexandria, VA: Institute for Defense Analyses.

Quensel, S. L., Myers, W. E., Koger, M. E., Nepute, J. T., Brewer, J. D., Sanders, J. J., Crumley, K. A., & Sterling, B. S. (1999). *Development of a Refined Staff Group Trainer* (ARI RR 1735). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.10 Performance Objectives Methodology

To prepare for a CTC or other large-scale exercise, a unit must identify the collective activities to focus on that will give them the greatest return on the time and effort invested in their preparations. The performance objective effort (Jenkins, Graves, Deter, & Quinkert, 1999) focused on critical techniques and procedures and provided flexibility to tailor the exercises to address specific unit training needs. The objectives target high-payoff performance and procedures, collective behaviors that require interaction and synchronization, and the techniques and procedures that are known to experts but not contained in published doctrine. They are usually multiechelon, and cover whole series of events and activities that occur over an entire exercise or a significant part of an exercise as the situation is developed. The basic process for developing performance objectives is outlined below.

Step	Activities
1. Identify Candidate Topics	Review sources: • Lessons learned from CTCs, discussions with CTC personnel and unit leaders, TTP publications, battlefield function (BF) analyses, etc. • Down-select based on criticality, acceptability, feasibility, and nonredundancy. • Outline selected objectives in terms of who, what, when, what, how, why. • Clearly define objective and supporting tasks. • Indicate appropriate training participants. • Observable within scenario and simulation environment. • Consistent with doctrine.
2. Prepare techniques and procedures	Prepare guidance on how the objective can be achieved, based on literature review, roleplay enactments, expert input.
3. Integrate techniques and procedures in TSP	Prepare event sheets to identify prompts, cues, messages and instructions to cue activities. Prepare performance objective observation guidance with assessment guide (indicators of performance).

Reference:

Jenkins, S. N., Graves, C. R., Deter, D. E., & Quinkert, K. A. (1999). *Development of the COBRAS III Performance Objectives for the Brigade and Battalion Staff Exercise* (ARI RP 99-03). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.11 Train-the-Trainer: Developing Guidance for Observers, Controllers, and Interactors

Campbell, Campbell, Sanders, Flynn, & Myers (1995) documented a process for preparing guidance for observers, controllers, and interactors supporting structured simulation-based training programs.

Phase	Focus Areas
1. Analysis	Training requirements – based on • Role (observer, controller, interactor, or combined). • Content and intent of the exercise. • Training objectives. • TSP materials for preparation, execution, and feedback. • Simulation. Audience • Level of experience *re* training, simulation, unit type, and mission. • Organizational structure of training support personnel (if any). • Numbers of support personnel training participants. Resources • Time allotted for train-the-trainer sessions. • Delivery media and methods. • Instructional staff personnel.
2. Design	Training outline • Objectives. • Sequence and time allotted to each objective. • Training events. Observer/Controller/Interactor TSP outline. • Handbook and job aids. Training media and methods plan • Simulator/simulation and multimedia support. • Classroom, classroom plus hands-on, or distributed. • Individual or group.
3. Development	Prepare TSP materials. Pilot test the training with representative support personnel; revise as needed.
4. Implementation	Plan • Prepare agenda (aka program of instruction [POI]). • Select facilities and instructors. • Identify training material quantities needed. • Notify participants. Prepare • Reserve and set up facilities. • Rehearse instructors. • Copy materials. • Confirm training schedule with participants. Execute • Do it.

Phase	Focus Areas
	• Reevaluate agenda and training plan continually (daily). • Consolidate loose ends daily. • Observe training for evaluation purposes.
5. Evaluation	Formative Evaluation • Interviews, questionnaires, and observations on the Train-the-Trainer sessions. Summative Evaluation • Interviews, questionnaires, and observations on the implementation of the structured training program.

Reference:

Campbell, C. H., Campbell, R. C., Sanders, J. J., Flynn, M. R., & Myers, W. E. (1995). *Methodology for the Development of Structured Simulation-Based Training* (ARI RP 95-08). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.12 High Impact Transfer Technology

The process below, derived from Finley, Sanders, and Ryan (1996, p. 235) describes a two-phased training development process that incorporates training transfer principles in developing courses of instruction.

Phase	Procedure
1. Task generalization: Analysis phase	a. Prepare objects and verb lists. b. Develop generalized components and objects lists. c. Describe generic action statements. d. Describe knowledges and skills groups associated with the generic action statements.
2. Generic design	a. Develop and sequence generic terminal learning objectives. b. Develop learning specifications. c. Develop syllabus. d. Develop lesson materials.

Reference:

Finley, D. L., Sanders, M. G., & Ryan, A. J., III (1996). Application of Training Transfer Principles in Developing the High Transfer Training (HITT) Methodology. *Innovations in Education and Training International, 33*, 232-239.

D.13 Training Support Code Methodology

Burnside (1990) developed a rule-based method for assessing Army Training and Evaluation Program Mission Training Plan (ARTEP-MTP) standards that can be met and subtasks and tasks that can be performed in training devices and simulations. The training support code (TSC) method was applied to assess the performance capabilities of the Simulation Networking (SIMNET) system, and results indicated that the method could be used to identify key tasks for training effectiveness and to assess the effects of system enhancements in terms of additional tasks to be trained. The method has also been applied to identify tasks for training in the Close Combat Tactical Trainer (CCTT). A summary of the assessment method is provided below.

Analysis Step	Procedure
1. Task Framework	Determination of the tasks to be considered
2. Standard Criteria	Rating of degree to which each task element or standard can be performed or met in the simulation: a. Highly supported – standard can be met entirely. b. Partially supported – standard can be met to a large extent. c. Minimally supported – standard can be met to a limited extent. d. Outside support required – standard can be met, but at least half of required actions must be performed outside the simulation. e. Not supported – standard cannot be met.
3. Decision Rules	Consolidation of ratings into subtask and task assessments through application of decision rules (see Burnside, 1990 for list of decision rules)
4. Review and Coordination of Ratings	Submission of ratings to SMEs for review

Reference:

Burnside, B. L. (1990). *Assessing the Capabilities of Training Simulations: A Method and Simulation Networking (SIMNET) Application* (ARI RR 1565). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.14 Evaluating Virtual Environment Training Capabilities

Sticha, Campbell, and Knerr (2002) developed a methodology for estimating whether the capabilities of virtual environment technology are sufficient to allow training of a specified set of activities. The methodology, known as *Satisfying Training Requirements in Virtual Environments (STRIVE)*, modifies and extends the TSC method by incorporating a simple behavioral analysis that is focused on the aspects of military tasks that are likely to present difficulty to virtual environment training.

The STRIVE methodology was presented in the context of the Integrated Definition (IDEF0) system analysis. The methodology is described below in terms of activities, what they produce, what they use for input, and how they are constrained by other information.

Activity	Description
Select Analysis Level	This activity determines whether the elements rated in the analysis should be tasks, task steps, performance measures, or some combination of these three. **Input**: List of tasks, each broken into task steps and performance measures. **Activity**: SME decides, based on task documentation, which tasks can be rated as single units, which tasks can be rated at the task step level, and which steps need to be broken down further to individual performance measures. **Output**: List of tasks, task steps, and performance measures that will be rated.
Select Relevant Technology Dimensions	In this activity, the SME answers some general questions about the training domain. The answers are used to select the technology dimensions that will be evaluated. **Input**: Eight dimensions that describe capabilities of virtual environment technology: • Visual display resolution. • Manipulation of terrain. • Manipulation of equipment. • Scene complexity (if operating dismounted). • Gesture recognition (if operating dismounted). • Tactile/force cues (if operating dismounted). • Ability to operate both mounted and dismounted. • Speech recognition. **Activity**: Describe performance requirements of the tasks. **Output**: Decision on relevant capabilities needed.
Determine Available Capability	The purpose of this activity is to determine whether there are any design constraints that might affect the performance that is possible using virtual environment technology. **Input**: Relevant capabilities (from previous activity) **Activity**: Describe design constraints in terms of speech recognition, transportability, and reconfigurability. **Output**: Identification of available capabilities

Activity	Description
Rate Task-Element Coverage	In this step the SME answers several questions regarding each of the task elements to be rated. Each question relates to one technology dimension. A score is calculated that represents the extent to which the capabilities of that dimension support the activities conducted in the rated task element. **Input**: Task elements, relevant and available capabilities. **Activity**: Answer questions specific to the relevant dimensions for each task element. **Output**: Rating of performance support for each task element. The rating is the minimum for all of the dimensions rated for the element.
Aggregate Ratings to Task Level	The method uses a rule system to determine numeric scores for each task, task step, and performance measure based on the ratings computed in the previous step. SME input is then applied to refine the score. **Input**: Rating of performance support for each task element. **Activity**: SMEs indicate, for each task step, the importance of training that step in a virtual environment; these judgments are used as weights in computing task trainability ratings. **Output**: Task trainability ratings, consisting of weighted and aggregated support ratings.

Reference:

Sticha, P. J., Campbell, R. C., & Knerr, C. M. (2002). *Training Concepts for Virtual Environments* (ARI SR 2002-05). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.15 Identifying Core Set Exercises

Gossman, Graves, Mauzy and Clagg (2001) examined the management and assessment of user-produced TSPs to provide the basis for design of TSP development tools. In addition to describing TSP components and TSP assessment, distribution, and maintenance requirements, they also specify a methodology for identifying exercises that would comprise a core set for different user audiences. The methodology is described below.

Step	Description
1. Specify Unit Type	Identify the unit for which the core set is being specified, in terms of branch and echelon.
2. Select Viable Training Methods	Determine viable training methods, in terms of specific exercise types and training environments, for the unit. Figure 4 in the report shows the domain of exercise types and environments, and Table 1 demonstrates rationales for determining viability.
3. Identify Training Focus	Beginning with a domain list of possible training content (e.g., the appropriate MTP), filter the list by deciding if each task should be the focus of an exercise or trained in the context of another task. Group tasks into combinations that can be sequenced into realistic battlefield storylines by identifying how tasks actually occur and identifying tasks that can be trained together.
4. Identify Specifications for Collective Training	Analyze storylines (Step 3) and viable methods (Step 2) to identify the full set of possible types of exercises by determining whether each method supports the tasks and whether the resulting training would be efficient.
5. Develop a Core TSP Set	Identify the specific exercises that comprise the core set, based on the analysis in Step 4. by selecting from among the possible methods and tasks. (The eventual goal is to have TSPs for all storylines and methods identified in Step 4, but it would be impractical to develop all of the exercises at one time.)

Reference:

Gossman, J. R., Graves, C. R., Mauzy, R. P., & Clagg, R. A. (2001). *Assessing and Managing User-Produced Training Support Packages* (ARI RR 1772). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.16 Training Program Conversion

Graves et al. (1999) took another look at the basic methodology for developing structured simulation-based training (Campbell, Campbell, Sanders, Flynn, & Myers, 1995), modifying it to address the need for converting existing analog training to digital. The conversion approach was then implemented for three specific conversion instances; the report provides details on the process, descriptions of the products, and lessons learned. The basic process, as further revised to address conversion efforts in general, is outlined below.

Step	Activity
1. Conduct Front-End Analysis	Define the "old" (e.g., conventional) training in terms of – • Environment (simulated mission, enemy, terrain, troops, time, and civilian considerations [METT-TC]). • Purpose of the training. • Training audience. • Training conditions (specific training environment). Define the "new" (e.g., FCS) training in terms of – • Environment (simulated METT-TC). • Purpose of the training. • Training audience. • Training conditions (specific training environment).
2. Develop the Conversion Plan Document	Identify procedures and conditions • Identify areas for content changes. • Identify components to be modified. • Identify procedures for specifying and implementing conversions.
3. Design and Develop New Product	Execute the Conversion Plan • Specify design and structure. • Develop TSP. • Conduct formative evaluation.

References:

Campbell, C. H., Campbell, R. C., Sanders, J. J., Flynn, M. R., & Myers, W. E. (1995). *Methodology for the Development of Structured Simulation-Based Training* (ARI RP 95-08). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Graves, C. R., Pratt, D. M., Campbell, C. H., Allen, J. D., Thorson, K. G., Jenkins, S. N., & Quinkert, K. A. (1999). *Force XXI Training Program - Digital Project: Report on Development and Lessons Learned* (ARI RR 1748). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.17 Refined Training Analysis and Feedback Center of Excellence Concept

The refined Training Analysis and Feedback Center of Excellence (TAAF-X) (Anderson, Begley, Arntz, & Meliza, 2000) helps clarify CTC and homestation responsibilities. This refined concept assigns functions that the TAAF-X TAF analysts are responsible for, clarifies the roles of the analysts at the local tactical analysis facility (TAF), specifies the echelons supported at CTCs and homestations, and establishes assumptions necessary to make the TAAF-X viable. The division of labor is presented below, followed by a summarized list of potential problems that would prevent implementation of TAAF-X and their solutions (both adapted from Anderson et al.).

Division of Labor in the Refined TAAF-X Concept

TAAF-X Analysts	• Collect TAF analyst requirements for AAR products. • Prepare and transmit AAR products to TAF analysts for O/C presentation. • Produce take home package based on input from TAF analysts and O/Cs. • Publish and deliver take home package to rotational units. • Provide Center for Army Lessons Learned (CALL) access to rotation data.
CTC/Homestation TAF Analysts	• Perform all necessary exercise control functions. • Coordinate with O/Cs for AAR requirements from AAR products list and forward AAR products requirements to TAAF-X for construction. • Review and send final AAR products from TAAF-X to O/Cs for use in AAR presentation. • Compile O/C and analyst comments and observations then forward to TAAF-X for inclusion in take home package.
O/Cs	• Assist the local analyst in exercise control functions. • Notify the supporting analysts what type of AAR product they need. • Provide input to changes and refinements to AAR products list as required. • Mentor and coach unit players.

Potential TAAF-X Implementation Problems and Possible Solutions

Potential Problem	Possible Solution Strategy
Analysts lack time to support additional units	Strategy 1: Implement automation strategies described in the advanced tactical engagement simulation concepts (ATESC), cognitive requirements for information operations training (CRIOT), and advanced after action review media (A3RM) reports.
Differences in AAR systems among sites	Strategy 1: This problem will be addressed with the fielding of the CTC objective instrumentation system (OIS).
Delays in communication with TAAF-X	Strategy 1: Provide an automated system at the CTCs with limited AAR production capability, such as for statistical aids and for text slides. Strategy 2: Require each O/C to create his own AAR product for inclusion in the AAR. Equip him with a laptop, presentation software and a way to send/receive e-mail. He would create his products and send them to the AAR facility for senior O/C review and inclusion/deletion.
Selection of AAR aids from standard list reduces O/C	Strategy 1: The automated system for preparing "standardized" menus of AAR aids should be given an editing capability that matches the variety of

Potential Problem	Possible Solution Strategy
flexibility	changes O/Cs are likely to make. Strategy 2: Be prepared to have TAAF-X analysts spend a certain portion of their time preparing requested, unique AAR aids for an exercise. (The O/C requesting the aid could possibly identify a new type of aid that TAAF-X adopts if it meets an information need not being met by existing aids.)
Distractions in homestation training will lead to inefficient use of TAAF-X	Strategy 1: TAAF-X can use down time resulting from cancellation of exercises to prepare lessons learned reports in cooperation with CALL. Strategy 2: Reinforce the chain of commands commitment to reduce training distractions at all levels within units. Leaders from the Division Commander level down to Squad Leader level should put more emphasis on training, ensuring nothing interferes with planned training.
Unit leaders may not want information about their unit's performance going to a central site	Strategy 1: Encrypt all data from the instrumentation system (IS), tactical engagement simulation (TES), and CTC TAF/Homestation TAF workstations. Strategy 2: Run dedicated lines from TAAF-X to all supported installations. Strategy 3: Use both Strategy 1 and Strategy 2.
The need to consider differences in range, resource constraints, and operational equipment among training sites may overwhelm TAAF-X analysts	Strategy 1: Restrict the number of training areas with which each analyst normally works. Strategy 2: Prepare database with training area specific information (locations normally used for defensive positions, etc.). Strategy 3: Limit the number of exercises an analyst supports during a given period to one.
Procedures and AAR techniques vary greatly among sites	Strategy 1: Coordinate with CTC and homestations to determine a standard presentation sequence for AARs. Train all O/Cs and TAF analysts in AAR presentations in the same manner. Strategy 2: Re-establish AAR presentation guidelines and doctrinal formats to ensure specific procedural requirements are maintained.
Difficult to adjust TAAF-X staffing to match workloads	Strategy 1: Create a TAAF-X cell for each exercise, coordinating local analyst duty times and manning with TAAF-X duty times and manning. Strategy 2: Man the TAAF-X around the clock, using a three or four-shift rotation of personnel with equal numbers of analysts in each shift.
Terminology for AAR aids and organization of TAF cells vary among CTCs	Strategy 1: The standardization of the terminology and organizations of the TAF cells at the CTCs and homestations will improve the TAAF-X's ability to support all units.
Potential lack of homestation analyst training	Strategy 1: Homestations should provide continuity in terms of the personnel tasked to serve as local analysts to reduce the costs associated with analyst training.
Potential lack of homestation O/C training	Strategy 1: At a minimum, homestation O/Cs should receive a brief introduction to the types of AAR aids available from TAAF-X and their utility (e.g., traces of unit movement provide a fast way to show a unit wandered or backtracked during movement).
Lack of an O/C and homestation analyst habitual relationship	Strategy 1: Assigning personnel to work as local analysts for extended periods will help to alleviate this problem.

Potential Problem	Possible Solution Strategy
Lack of a TAAF-X analyst and homestation analyst habitual relationship	No strategy identified.
Potential lack of TAAF-X analyst training	No strategy identified.
TAAF-X Analysts may be overwhelmed with AAR product requests	Strategy 1: Disperse start times for exercises assigned to a TAAF-X analyst or TAAF-X analyst cell to minimize overlap during the most frantic AAR aid preparation periods. Strategy 2: Provide tools to help TAAF-X analysts track AAR aid preparation activities for multiple exercises concurrently. Strategy 3: Provide some level of AAR preparation capabilities at local training sites (local analysts will need workstation to perform exercise control functions).
Communication of AAR requirements to TAAF-X will be difficult if voice is the only communication media	Strategy 1: Video teleconferencing capabilities would improve the communication capabilities among O/Cs, local analysts and TAAF-X analysts.
Local analysts will be distracted by requirement to act as link between O/Cs and TAAF-X	Strategy 1: Video teleconferencing capabilities would improve the communication capabilities among O/Cs, local analysts and TAAF-X analysts.
Inexperienced O/Cs will impose a heavy AAR aid preparation requirement on TAAF-X	No strategy identified.

Reference:

Anderson, L. B., Begley, I. J., II, Arntz, S. R., & Meliza, L. L. (2000). *Training Analysis and Feedback Center of Excellence (TAAF-X)* (ARI SR 2001-01). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.18 Strategies to Reduce O/C Workload

Brown, Nordyke, Gerlock, Begley, and Meliza (1998) studied the requirements for exercise control and training feedback at CTCs and homestation. They found that the workload for trainers is becoming increasingly intensive, and identified 13 strategies for reducing or managing O/C and Training Analysis Facility workload.

Strategy	Description
1 – Automate NLOS battle damage assessment	Providing a non line-of-sight (NLOS) simulation modeling capability would require installation of sensors on actual indirect fire platforms to determine the tube azimuth/elevation and the type ammunition fired, but would remove the burden of observation and simulation manipulation from the analyst.
2 – Pair Designator to Target Designated	Similar to Strategy 1, for remotely designated engagements.
3 – Pair Shooter to Misses	Combining the pairings of hits/kills collected by the instrumentation system with the misses collected by the line-of-sight (LOS) simulation model can assist TAF analysts in assessing the distribution and massing of blue forces (BLUFOR) direct fires.
4 – Reduce pyrotechnics expended for NLOS battlefield effects	Extends Strategy 1 to a model that depicts virtual images of indirect fire on the live battlefield; integrates a heads-up virtual visor into the combat vehicle command (CVC) helmet to portray virtual 3D visual effects and incorporates sound as well.
5 – Overcome limitations of laser technology	Virtual mirroring could produce virtual firing signatures and terminal effects for LOS and NLOS engagements using the virtual visor and headphones. This will eliminate laser transmitters and receivers, most pyrotechnic requirements, and reduce feedback requirements.
6 – Provide a Virtual opposing force (OPFOR)	Inserting a virtual OPFOR on a live battlefield has great potential for homestation live training, where maneuver area restrictions and live units to serve as OPFOR severely limits the scope.
7 - Provide tactile feedback	Participants need devices that provide tactile feedback in response to the varying degrees of energy received form non-lethal weaponry.
8 – Automate C4I data collection and control	To provide extrinsic command, control, communications, computer, and intelligence (C4I) feedback, the instrumentation system must capture all digital traffic transmitted and received by every player node and filter the information for significant BLUFOR digital actions or inactions.
9 – Automate tracking of player activities and expended resources	By tracking the use and consumption of simulated resources from the support area to final destination, O/Cs and analysts are able to track activity and use of resources.
10 – Automate TES system monitoring	Automating TES system testing will provide more consistent testing, reduce O/C workload, and enhance the credibility of the exercise.

Strategy	Description
11 – Automate AAR preparations	By determining typical O/C and analyst subjective assessments and identifying typical AAR aids that support each assessment, a knowledge base can be developed that contains algorithms and AAR formats.
12 – O/C control, observation, and future battle command brigade and below (FBCB2) Workstation	O/Cs need a mobile workstation to support their control and observation requirements. The workstation should support the O/C's control and coordination needs and provide the O/C the capability to monitor the unit's digital activities.
13 – TAF analyst workstation	An instrumentation system that archives 2D and 3D computer-generated imagery, video, audio, C4I digital data, and all email and digital reports exchanged among O/Cs and analysts are needed.

Reference:

Brown, B. R., Nordyke, J. W., Gerlock, D. L., Begley, I. J., II, & Meliza, L. L. (1998). *Training Analysis and Feedback Aids (TAAF Aids) Study for Live Training Support* (ARI SR 98-04). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.19 Evaluating TSP Components

When units produce TSPs, either by creating a new one or by modifying an existing one, several levels of assessment may be needed. Gossman, Graves, Mauzy, and Clagg (2001) present an approach to assessment that defines the levels and the criteria for assessment at each level. The first three levels should be conducted for any user-produced TSP; the last two come into play only if the TSP is a candidate for distribution to other units. The approach is outlined below.

Assessment Level	Criteria
Unit assessment – conducted by commander or parent organization	Is the exercise ready to run? • Does the exercise match the unit's training needs? • Is the exercise tactically and doctrinally correct? • Are the mission essential task list (METL) tasks and supporting collective and individual tasks addressed adequately? • Does the exercise utilize the training environment best suited to the unit's training needs? • Are the resources adequate to conduct the training? • Are safety and environmental issues addressed? • Are sound training principles incorporated?
Site assessment – conducted by simulation site personnel or system operators	Is the exercise technologically correct? • Are initialization conditions correct? • Are timings correct? • Is entity count within bounds? • Do events and effects occur as planned?
Execution assessment – conducted by commander and other users	How did the exercise work when executed? • Did events and effects occur as planned? • Did the TSP have all necessary information? • Were cues adequate to require unit performance as planned?
Proponent assessment – conducted by TRADOC organization responsible for distribution	Does the exercise meet criteria for inclusion in the centralized database/repository? • Is the exercise tactically and doctrinally correct? • Are sound training principles incorporated? • Is this exercise substantially different from others in the database? • Are all necessary TSP components included? • Is the exercise packaged properly for electronic distribution?
Selection assessment – conducted by unit commander prior to adopting an exercise from the repository	Does the exercise significantly meet unit training needs? • Does the exercise match the unit's training needs? • Is the exercise tactically and doctrinally correct? • Are the METL tasks and supporting collective and individual tasks addressed adequately? • Does the exercise utilize the training environment best suited to the unit's training needs? • Are the resources adequate to conduct the training? • Are safety and environmental issues addressed?

Reference:

Gossman, J. R., Graves, C. R., Mauzy, R. P., & Clagg, R. A. (2001). *Assessing and Managing User-Produced Training Support Packages* (ARI RR 1772). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.20 Training Effectiveness Analysis Methods

Morrison and Hammon (2000) classify training effectiveness analysis methods by the research operations used and the types of data collected. The three broad categories are described below; the report also includes examples of the use of each method.

Method	Description
Training Surveys	Usual method for obtaining user reactions, where users include not only trainees, but also managers, unit commanders, and trainers.
Empirical Performance-Based Research Designs	Most highly respected approach for measuring training effectiveness but also the most resource intensive. Three basic types: 1. Randomized (true) experiments – require random assignment of participants to experimental treatments (e.g., training approaches), as well as pre- and post-training measurements. Allows the researcher to make strong inferences about cause-effect relationships between the training conditions and the performance measures. Includes: a. Learning experiments – used to determine the amount of learning that occurs as a direct result of training on the simulation system, by comparing pre- and post-training test scores. b. Transfer experiments – used to assess the degree to which learning on the training system transfers to and improves performance in the operational setting. 2. Quasi-experimental designs – involves systematic use of intact comparison groups rather than random assignment to experimental conditions. 3. Correlational studies – involves passive observation or assessment of levels of training, rather than control of experimental conditions.
Training Analyses	Method for estimating the training effectiveness of training systems. A key characteristic is reliance on nonemperical data (i.e., data other than those derived from actual performance or user input). Includes: 1. Training system estimation models – based on the assumption that a training system can be evaluated in terms of its elements and that the benefits of a training system can be understood by studying those elements. These methods are usually complex and costly. 2. Modeling – refers to the analyst's attempts to represent accurately and economically the key characteristics of the training system. 3. Analogy – by which the analyst infers the effectiveness of a training system by examining the effectiveness of a similar system. 4. Extrapolation – prediction based on some understanding about how a process works. 5. Task list analyses – evaluation of training devices in terms of the tasks they can train.

Reference:

Morrison, J. E. & Hammon, C. (2000). *On Measuring the Effectiveness of Large-Scale Training Simulations* (IDA Paper P-3570). Alexandria, VA: Institute for Defense Analyses.

D.21 Diagnostic Indicators of Digital Proficiency

Meliza (In Preparation) presents 15 diagnostic indicators of digital proficiency that cut across specific digital skills. For each indicator, Meliza also provides several tasks that are indicative of level of proficiency. The indicators, along with brief descriptions, are provided below.

Indicators of Basic Digital Proficiency	Description
1. Taking actions to ensure connectivity.	Maintaining a high level of connectivity requires command emphasis down through the ranks. A unit that falls too low with respect to this activity is digitized in terms of equipment but not in terms of linkages or behaviors.
2. Displaying confidence in the robustness and value of digital systems.	The unit will take actions to allow a rapid return to digital operations if there are crashes if the effort required for digitized operations is viewed as being worth the value obtained from the system.
3. Using digital systems to ensure timely distribution and review of planning products.	The amount of effort a unit puts forth to put planning products in front of decision makers and unit leaders as soon as possible is an indicator of digital proficiency.
4. Appreciating the value of digital capabilities.	The greater the perceived contributions to tactical performance, the more likely that individual systems are ensured to be operational.
5. Using digital systems to apply tactical task triggers.	A potential benefit is the capability to employ trigger events that can be observed using situational awareness (SA) displays. If a unit does not employ digital systems during rehearsals, it is unlikely that the rehearsal will reveal any information about possible digital triggers.
6. Ensuring adequate monitoring of digital displays.	Strategies for periodically checking SA displays and/or delegating the responsibility are an important indicator of digital proficiency.
7. Tailoring views of the battle-space to fit visualization objectives.	Systems need to be tailored to meet leaders' information requirements.

Indicators of Advanced Digital Proficiency	Description
8. Using terrain analysis tools to support tactical decisions.	A critical variable appears to be understanding what decisions can be supported by software and what decisions require a physical terrain reconnaissance.
9. Integrating digital systems into rehearsals.	As a unit gains more experience, digital systems may provide a means of showing what the tactical situation will look like during mission execution.
10. Using digital displays to monitor/control unit movement.	Leaders can use digital displays to decide whether their subordinates are moving to the correct location; using the appropriate formation, at an appropriate speed; maintaining an appropriate degree of dispersion; and moving and halting when they should.
11. Actively maintaining awareness of the threat situation.	As a unit progresses digitally, digital contact reports with geo-referenced icons can be expected. The more a unit employs digital capabilities to track the threat situation, the more work a unit has to perform.

Indicators of Advanced Digital Proficiency	Description
12. Using digital tactical SOPs to facilitate communication and visualization.	Without SOPs to guide file-naming conventions, it will be difficult to manage information, maintain a network, and create a common picture of the tactical situation.
13. Using effective mixes of reporting modes.	In many cases, units should use digital messages in combination with voice messages.
14. Delegating digital tasks to ensure adequate employment of digital systems.	Delegating responsibility of tasks that use digital systems is a good indication that a unit is digitally proficient.
15. Organizing digital data to facilitate communication.	Until units progress to the point where they push electronic copies of planning products down to company and platoon levels, there is little data to organize.

Reference:

Meliza, L. L. (In Preparation). *Digital Skills and Indicators of Overall Digital Proficiency.* Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.22 Factors Impacting Digital Proficiency

Meliza (In Preparation) describes five variables that influence how far a unit progresses in terms of digitization. Changes in the variables below are expected to impact digital proficiency.

Variables Affecting Progress in Unit Digitization	Questions to Answer Before Training
1. Changes in digital system capabilities a. Increased robustness b. Features better designed to meet users' needs	Are system operators aware of changes in capabilities and application problems between the current version and last version of the digital system? Does the version of the digital system used in the training situation match the current operational version used by the unit?
2. User understanding of and appreciation for digital capabilities c. Greater tactical benefits d. Requirement to maintain high rate of connectivity among digital systems e. Requirement for scenario situation that sets the stage in order to gain certain benefits	What capabilities do users plan to employ? What capabilities are users unlikely to employ?
3. Digital training strategies	What training have leaders and soldiers had regarding system capabilities? What capabilities have been used and rewarded in the context of an exercise?
4. Digital SOPs	Does the unit have SOPs addressing conventions for naming planning products? Does the unit have SOPs addressing setting filters and other digital options? Does the unit have SOPs regarding the delegation of digital tasks to specific duty positions or individuals?
5. Legacy behaviors	Do unit leaders use digital line-of-sight tools? At what point does the staff begin including planning products within the digital network?

Reference:

Meliza, L. L. (In Preparation). *Digital Skills and Indicators of Overall Digital Proficiency.* Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.23 Usage Considerations for Embedded Training and Performance Support Systems

Although many researchers discuss use of ET or EPSS, there is no comprehensive listing of when these methods are appropriate. Throne and Burnside (2003) present a consolidated list of considerations, gathered from various sources. Since there are numerous similarities between these two types of performance enablers, suggestions gathered from EPSS and ET writings are likely to apply to both fields. Embedded training and EPSS are most useful when some or all of the following conditions exist:

- Computers will be used regularly in task performance.
- A majority of the work is mental rather than physical.
- Personnel turnover is high.
- Current training is insufficient.
- Training costs need to be cut.
- Job performance needs improvement.
- Supporting information is difficult to access.
- System users are geographically dispersed.
- On-the-job training is important.
- The user will be engaging in complex tasks.
- The users are not closely supervised.
- Mistakes in task performance are costly.
- The organization is downsizing.
- Users have diverse learning styles.
- Users need access to experts to perform their jobs.
- Information and technology explosions have occurred.
- Expectations for performance are high.

Reference:

Throne, M. H. & Burnside, B. L. (2003). *Integrated Training and Performance Support for the Objective Force* (ARI RR 1801). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.24 Design Guidelines for Embedded Training and Performance Support Systems

Once the decision has been made to use ET and EPSS, training developers will need a set of guidelines for building appropriate performance enablers. The guidelines below, compiled by Throne and Burnside (2003) from writings on ET and from the FCS system training plan ([STRAP] draft, August 2002), are based on capabilities that should exist for success in both EPSS and ET efforts. Embedded training and EPSS capabilities should have the following characteristics:

- Be fully compatible with the prime system.
- Be as fully integrated with the prime system as possible.
- Not endanger personnel, equipment, or data through incorrect operator actions.
- Not compromise security of the system or its data.
- Have minimal impact on the prime system's reliability, availability, or maintainability.
- Not lead to negative transfer in the operational mode.
- Enable combined arms and joint, interagency, and multi-national (JIM) proficiency.
- Leverage UA network architecture.
- Allow on-demand access (reach) to doctrine and TSP repositories.
- Provide collaborative wargaming tools, supporting mission planning and rehearsals, while deployed or deploying.
- Provide required tactical engagement simulation for the full range of weapons, including electronic warfare.
- Provide CTC-like instrumentation: data capture, management, and analysis, along with rapid feedback.

References:

Throne, M. H. & Burnside, B. L. (2003). *Integrated Training and Performance Support for the Objective Force* (ARI RR 1801). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Unit of Action Maneuver Battle Laboratory. (2002). *Operational Requirements Document for the Future Combat Systems (Draft, 30 Aug 02).* Fort Knox, KY: Author, U.S. Army Armor Center and Fort Knox.

D.25 AAR Aids

Brown, Nordyke, Gerlock, Begley, and Meliza (1998), in their study of requirements for exercise control and training feedback at CTCs and homestation, developed concepts for a number of AAR aids. The automated AAR system would allow the analyst to access the aids in the database that support the O/C's subjective assessment. As the library of aids grows in number and sophistication, the system could categorize assessments by tactical mission, BOS, operational activity (e.g., planning, execution). Nine such aids are illustrated in the report (pp. 80-86) for a battalion task force assault, and are described below.

AAR Aid	Description
1 – Task Standards	The performance measures for the task or task steps that most closely matches the subjective assessment.
2 – Mission and Execution Plan	A short statement of the mission and a graphic (top-down) depiction, with graphic control measures, of the plan for execution.
3 – Battle Outcome	Bar graph showing BLUFOR and OPFOR operational systems at the beginning and end of the battle.
4 – Direct Fire Distribution	Shows BLUFOR direct fire distribution during assault on the objective, along with candidate questions the O/C may ask to generate discussion.
5 – Voice Fire Commands	Replays clips of the BLUFOR assault from a top-down view, with synchronized audio from the tactical voice net, isolating fire commands issued by selected commanders.
6 – Indirect Fire Distribution	Graphic (top-down view) of distribution of smoke and casualty-producing munitions, with candidate AAR questions.
7 – Video of Smoke	Graphic (out-the-window) portrayal of smoke distribution, revealing whether BLUFOR smoke obscured the vision of the OPFOR vehicles, with candidate AAR questions.
8 – Effectiveness of Support by Fire Elements	Line graph showing effectiveness in suppressing OPFOR fires and protecting the assaulting elements, with candidate AAR questions.
9 – Coaching Guide	Coaching points to support more directive assistance from the O/C on how to improve performance.

Reference:

Brown, B. R., Nordyke, J. W., Gerlock, D. L., Begley, I. J., II, & Meliza, L. L. (1998). *Training Analysis and Feedback Aids (TAAF Aids) Study for Live Training Support* (ARI SR 98-04). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.26 Cognitive Learning Strategies

Sanders (2001) provides a summary of cognitive learning strategies identified in the literature on cognitive processes. A key feature of these strategies is that the learner is an active participant in the learning process. By offering multiple learning strategies within a training program, students can better achieve their learning goals. Listed below are the nine cognitive strategies (adapted from Sanders, p. 12).

Learning Strategies	Description
Chunking	Rational ordering, classifying, or arranging of complex arrays preparatory to deeper processing.
Frames 1	A matrix, grid, or framework for representing knowledge organized by a spatial strategy. Facilitates comparisons and contrasts. Presents holistic cognitive structure for material.
Frames 2	A matrix organized by some lawful principle, allows use of logic or inference to fill in missing information.
Concept Map	Graphics reveal the structural pattern in the material, provide the "big picture." Aids the recall of detail. Computers good in allowing flexible presentation of material and relationships.
Advance Organizer	Presented prior to new material. A brief transition statement identifying connections between prior learning and new material.
Metaphor	Sensitizes student to similarities between something known and something new. Helps learner transfer prior knowledge to another topic. Helps sensitize learner to similarities across knowledge arrays.
Rehearsal	Activities to keep material active in consciousness to support transition into short-term memory. Supports deeper processing for long-term recall. Gets learner actively, intellectually engaged in processing information, not just passively exposed to information.
Imagery	Cognitive strategy that aids recall. Mental pictures learner forms to aid recall. A key way of storing information in the mind, images can hold large amounts of information and great detail.
Mnemonics	Artificial aids to memory used with material low in structure until meaningful mental structures developed.

Reference:

Sanders, W. R. (2001). *Cognitive Psychology Principles for Digital Systems Training.* (ARI RR 1773). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.27 System Improvement Recommendations

In 1998, a concept experimentation program (CEP) was conducted by the Mounted Battlespace Battle Lab (now the Unit of Action Maneuver Battle Laboratory) to assess battle command information requirements and military decision making in the 2010-2015 timeframe. Lickteig, Sterling, Elliott, Burns, and Langenderfer (1998) collected recommendations on how to improve C4I systems to better meet battle command information requirements from the CEP participants; they are presented below.

	***Mission* Component Recommendations on Information Requirements**
Warning Order	• Standardized format with more detail. • Ability to manipulate the detail provided.
Operations Order	• Ability to extract or parse most relevant portions of a higher echelon order. • Wider dissemination of the brigade level operations order.
Operations Overlay	• Standard library of icon symbology. • More integrated C4I tool set to fuse information sources. • Integration of all mission related information into dynamic map overlays and displays.
Commander's Intent	• Clear delineation of priorities and end state. • Formats that provide clear understanding of the intended end state of the mission.
Course of Action	• Information formats that delineate and coordinate the sequence of actions. • More continuous linkage for Whiteboard-type communications to clarify and adjust activities during the course of operations.
Fragmentary Orders	• More continuous linkage for whiteboard-type communications.
	***Enemy* Component Recommendations on Information Requirements**
Location	• More extensive feed from higher echelons. • Dynamic linkage and match of enemy situation templates to depicted enemy locations.
Composition	• Additional information on vehicle and unit types. • Manual labeling capability to indicate composition.
Disposition	• Better information on enemy location and composition.
Ability to See	• Graphic depiction of "dead space" associated with enemy vehicles or icons provided as required.
Ability to Move	• More valid information on enemy's ability to move.
Ability to Shoot	• Information on enemy weapon ranges.
Ability to Communicate	• Information to identify vehicles with multiple antennas. • Information on estimated radio ranges adjusted for terrain.
Ability to Sustain	• Mission design entailing combat service support. • More extended mission operations.
	***Terrain* Component Recommendations on Information Requirements**
Observation	• Database to support requirements for observation.
Cover	• Cover information in more challenging relief.

Terrain Component Recommendations on Information Requirements *(continued)*	
Concealment	• Accurate terrain databases.
Obstacles	• Depiction of information required on manmade obstacles.
Key Terrain	• Capability to explicitly identify or mark key terrain features.
Approach Avenues	• Provision of approved graphic symbols for approach avenues. • Ability to annotate and delete graphics as required. • Automatic analysis and identification of approach avenues, adaptable to unit size.
Weather	• Scenario designs other than clear daylight conditions.
***Troop* Component Recommendations on Information Requirements**	
Location	• Distinctive color scheme for friendly icons and symbols to ease tracking.
Organization	• Labels indicating unit affiliations.
Ability to See	• Higher magnification for terrain database manipulation.
Ability to Move	• Information to improve understanding of trafficability.
Ability to Shoot	• Ability to directly observe firings by direct and indirect systems on the tactical display (i.e., engagement updates).
Ability to Communicate	• Ability to analyze radio ranges and assess need to retransmit. • More immediate communication, particularly for e-mail messages.
Ability to Sustain	• Inclusion of logistics. • Inclusion of combat service support.
***Time* Component Recommendations on Information Requirements**	
Plan	• Timelines for task force operations. • Capability to analyze time requirements or monitor progress in relation to timeline.
Wargame	• Automated capability to wargame potential courses of action.
Prepare	• Established timeline.
Rehearse	• Automated capability for unit to rehearse.
Execute	• Decision point tool. • Input and display decision points on tactical display. • Decision points coupled with automated check and feedback before designated decision points reached.
Synch Execute	• Digital version of synchronization matrix with dynamic format and automated updates.

Reference:

Lickteig, C. W., Sterling, B. S., Elliott, G. S., Burns, J. & Langenderfer, J. (1998). *Assessing Battle Command Information Requirements and the Military Decision Making Process: An Exploratory Investigation for the Mounted Maneuver Battlespace Laboratory* (ARI RR 1731). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

D.28 Leader Insights on Digitization and Transformation

Leibrecht, Johnston, Black, and Quinkert (2002) conducted a series of structured interviews with senior leaders in the Army's First Digital Division and used the information to prepare guidance on managing change in a number of focal areas. A brief summarization of selected insights, addressing the process of managing Force XXI transition as well as the transition's impact on tactics and doctrine, is shown below (adapted from pp. 24-44).

Managing Transition	Summary of Insights
Command Climate – Setting the Unit Tone	Create the unit as a learning organization where discovery and new ideas are prized. Accept risk as a positive factor, encourage people to think differently. Employ systems thinking: achieve efficiencies by setting priorities, rethinking all aspects of change – doctrine, leadership, soldiers, budgets, etc.
Command Climate – Motivating Leaders and Soldiers	Leaders need to mentor and empower their key people, demonstrate acceptance of digitization. Let people know that input is valued and feedback is being used. Manage expectations – early versions of systems are forerunners of the better ones. Major training events can be forcing functions, giving the unit anchor points for concentrating energy.
Command Climate – Setting and Protecting Unit Priorities	By establishing main and supporting axes, leaders can balance needs of the unit with needs of system developers, experimentation proponents, etc. Responding to the stress of high workload during transition by neglecting organizational management functions can cause major problems down the line.
Command Climate – Working With Others	During transition, there will be many stakeholders and interested observers, and the leaders need to be able to team with those outside the unit in order to remain knowledgeable about and responsible for solders being trained and ready. Support organizations and agencies need guidance from unit leaders on how they can best support the unit. Routine collaboration can help. Contractors who are working to introduce systems and operators who need to learn the systems need to work closely to facilitate transition. With tests and experimentation, there can be conflicts and misunderstandings about how training events are conducted.
Exploiting Digital Technologies	Although the initial learning curve for digitization can be steep, sound tactical skills and leadership talent remain the leader's greatest assets. Leaders must push for the system functionality they need. Committing to successful transition causes leaders and soldiers to find ways to make new doctrine and systems work. Forceful methods may be needed to jump-start transition, such as removing the means for doing things "the old way." To rein in the impact of system evolution, forceful control of software changes is imperative; leaders must communicate how software change impacts training, scheduling, and competing requirements.

Managing Transition	Summary of Insights
Infrastructure for Change – Army Culture	Groups with less history of change are slower to accept newer systems and will experience more frustration, which can be mitigated by experience-sharing among units. Preserving the "discovery" environment by delaying the rush to performance standards can actually help soldiers address the challenge of transition.
Infrastructure for Change – Enablers	Managing and implementing transition demands full-time dedicated personnel and transformational leaders who will focus on new ways of doing things. Innovative options for training and professional development will be necessary to keep up with rapid change.
Personnel	Leaders must continue to be warfighters, not technicians, and will need progressive assignments within the new environment. Mentoring for junior staff officers can encourage their excitement and development of vision. Young officers and soldiers, with high levels of comfort in computer environments, are crucial to transformation, but it should not be assumed that they will be comfortable with change. Long term (greater than a year) personnel stabilization can be effective in ensuring sufficient train-up before major events and an orderly transition afterwards. Additionally, continuous infusions of personnel generate a greater training and assimilation burden as constants such as standard equipment and consistent SOPs are less common. With a streamlined force, 100% fill is indispensable.
Training – Fundamentals	Large-scale training events can stress soldiers and leaders in ways that force them to exploit their new systems. Training in a transitional unit must address basic tactical (legacy) tasks as well as tasks on the new systems. Four factors that determine the rate of unit learning: frequency of repetitions, amount of enabling learning between repetitions, personnel stability, and consistent focus. In early stages of transition, the train-assess-train cycle must be repeated to identify what needs to be learned – especially with new equipment and organizational structures. Major transition events, including experimentation and testing, must be used as training events to advance readiness.
Training – Special Groups	During transition, special efforts are needed to train NCOs because many senior NCOs are not comfortable with the technology, and if they do not understand about skill acquisition and decay; it can hinder the transformation process. System training should be tailored to the position and responsibilities of the user but should also be conducted in the system-of-systems context.
Unit Organization- Reorganization Process	Reorganization, inevitable in transition, is a high-risk enterprise for the initial units because they have to determine how well the new structure works, and their feedback may lead to additional changes. There will be times during transition when reorganization is overlapping system changes, doctrine changes, and training developing, and the confusion is unavoidable. It does pass, however. A reorganized unit needs to invest energy in establishing new SOPs, and their need to be checks that the procedures are working.

Managing Transition	Summary of Insights
Unit Organization – Impact of Reorganization	People-oriented leaders find ways to implement reorganization without creating negative impact on individual warfighters (e.g., phased and sequenced company transitions with ample information).
Fielding New Systems	Experimentation brings non-standard equipment that evolves into modified tables of organization and equipment (MTOE) property, at which point support and maintenance become the unit's responsibility; this transition needs to be anticipated and planned for.
Documenting Critical Knowledge	Sharing information is critical, especially because discovery learning is the norm. Units undergoing transition play the pivotal role in developing TTP and doctrine. Obtaining valid assessment data and lessons learned demands a reasonable level of individual and collective proficiency on the new systems, which in turn requires a systematic training plan and a cutoff for system upgrades. An audit trial of unit transition issues, decisions, and successful and failed attempts to effect transition is indispensable if new leaders are to benefit from the experience of their predecessors. Transitional units tend to invest their lessons-learned energy in SOPs, and lessons about managing change and measuring progress may be lost.

Impact on Tactics and Doctrine	Summary of Insights
Impact of Technology	While the new digital tools were welcomed with enthusiasm, they are not magic. New systems provide better tools, but will not make up for a lack of basic warfighting skills. Digital tools' precision for visualizing enemy elements boosts the ability to recognize patterns on the battlefield and to set the conditions needed to destroy the enemy. Enhanced situational awareness enables bold and aggressive maneuver by giving the commander the confidence to move quickly and decisively. Signal operations may be the Achilles' heel of digital operations, and redundant signal companies may be required to enable repairs and restore connectivity.
Degraded Operations	Redundancy among systems can enable units to sustain operations even when specific technologies fail; when redundancy is not apparent, units will resort to conventional methods. It is not difficult to overrun the capacity of emerging systems, which can cause a virtual meltdown.

Reference:

Leibrecht, B. C., Johnston, J. C., Black, B. A., & Quinkert, K. A. (2002). *Managing Force XXI Change: Insights and Lessons Learned in the Army's First Digital Division* (ARI SR 2002-04). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.

Appendix E. Research Issues

The list of what we know, or think we know, is extensive, as evidenced even by the limited summary provided in this paper. What we don't know is yet more extensive, and we know it. Every experiment, study, observation, and program evaluation yields another set of interesting questions. A sampling of the more immediate needs, and some research-based guidance on addressing the needs, is presented here.

Performance issues

- The current decision-making model may be obsolete. What is the appropriate model in FCS that allows decisions to be made more quickly, within the enemy's decision-making cycle? What information does it use? How will it be trained?
- Distributed forces with better information at lower levels will both enable and require decision-making at lower levels. How will leaders learn to not only allow but empower subordinates to adapt to changing situations?
- With distributed teams, leaders may not come face-to-face with subordinate unit leaders for days. What will be the effect on command and control, and how can it be overcome?
- Command and control of robotic forces will increase the workload. Can one person handle both live and robotic subordinates? Or, if the robots are largely autonomous, what will be the effect on command and control?
- What methods can the soldier use to control off-board entities (robots)? Are multiple control methods necessary? Are they linked to levels of automation?
- Commanders and staffs must thoroughly understand how robotic forces work and what rules they follow in order to effectively employ them. What level of understanding will be sufficient? What is the best human-human and human-automation authority structure? How will automation affect the human leadership structure?
- Decision or performance aids will be developed. How will commanders and staffs develop a balance of trust and logical skepticism concerning the use of these aids? What decision tools will commanders need and want?
- "No increase in force structure" for FCS is not a useful mandate. The proper context for the discussion is the position that any increase in force structure must be justified by increases in the UA's relative combat effectiveness vis-à-vis a comparable baseline organization (legacy or Stryker). How will this be judged?

System issues

- The FCS will have the capability to assume some decision-making responsibility. What decisions can be made by the FCS (if any) and what must be made by the human? How does this relate to levels of automation? Does evidence show that the FCS features will, in fact, facilitate the soldier's decision-making?
- Vast amounts of information will be available to leaders, and they may need vast amounts for decision-making. Does the volume of information needed exceed the soldier's ability to process the information (information overload)?
- Does the workload under expected combat conditions exceed human capabilities? How will workload be affected by partial system failures?
- Information input could be diversified across human sensory modalities (e.g., visual, auditory, and possibly tactile). Will that help? How well can soldiers

integrate multiple sensor feeds from multiple positions and orientations? How can displays be designed to complement human sensory and information processing?

Training issues

- Structured training, both individual and collective, is frequently constructed using "nested" scenarios. Is there any real value to this approach? How damaging are the negative effects?
- How effective is distance learning? Do the benefits (if any) justify the costs? How disruptive are the negative effects?
- How should training requirements analyses change for digital tasks and for hybrid-conventional environments to determine the training needed for producing and sustaining high performance soldiers?
- What training methods work best to prepare soldiers for frequent software or equipment changes combined with ad hoc and varied missions (including combat and special assignments)?
- What methods work best to prepare leaders and to train widely dispersed soldiers linked as teams and units through digital networks?
- What methods work best to prevent skill decay? To retrain after skill decay? What timing of interventions works best?
- What measurement/assessment and feedback tools are needed to ensure that required skill levels are attained and retained?
- What training should be done how, when, and where using soldier-centered distributed/digital environments?

Methodological issues

- Large-scale simulations, for purposes of concept explorations or system experimentation, are too resource intensive and unwieldy to keep up with the pace of technological changes. Instead, what is needed is a mix of demonstrations, experiments, simulations, exercises, and formal tests.
- Testing and evaluation are hamstrung by the limited availability of soldiers and units with which to research and validate training, operational concepts, systems, organizational structures, and doctrine. Using simulation cuts down on some of the costs, and to be optimally useful the simulations should be reconfigurable to permit rapid prototyping.
- What is also needed is a designated experimental unit for research, in order to be able to focus on exploration and discovery of performance techniques. The formation of a shadow cadre to do concept exploration and testing would add value to the use of user juries. The approach could cycle unit members in and out, or a best-of-the-best model could be used.
- Investigate the extent to which change-driven knowledge gathered from one position in a particular unit can apply to other positions and units (or even be useful to others in same position/unit).
- Fully map knowledge requirements of change managers in various positions, echelons, and units.
- Apply the knowledge elicitation methodology to establish comprehensive multiechelon knowledge bases for other transition arenas (e.g., Stryker).